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THE BASIS OF PHYSIOLOGICAL INDIVIDUALITY IN ORGANISMS[1]

THE world of living things exists in the form of what we call in every-day language individuals. We must first inquire whether this word "individual," as applied to organisms or their constituent parts, has any real scientific value. Etymologically the word means something which is undivided or can not be divided, that is, it implies the existence of a unity of some sort. But divisibility is as truly a characteristic of the organic individual as indivisibility, for new individuals arise by processes of reproduction from parts of those previously existing.

How then do we recognize an organic individual? The answer is not difficult, though in certain cases it may be difficult to determine whether a particular organic entity is an individual or not. It is a certain unity and order in behavior in the broadest sense which characterizes the individual, either living or non-living. In the organic individual, whether it is a whole organism or part of it, this orderly behavior consists in a certain orderly arrangement of parts in space and a certain orderly sequence of events in time. The problem of organic or physiological individuality is then the problem of the nature of this unity and order.

Many attempts at the solution of this problem have been made. The so-called vitalistic and neo-vitalistic theories postu-

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late the existence of a non-mechanistic principle which controls and orders the physico-chemical activities. These theories have at least the merit of recognizing and meeting squarely the real problem, but while the present state of our knowledge does not permit a complete demonstration of their falsity, they are intellectually unsatisfying in many respects and particularly in view of the rapid progress of scientific method in its attack upon the problems of life.

The theories which postulate a multitude of distinct specific entities as the basis of the organism are properly speaking not theories of organic individuality at all, for they ignore the real problem. They are merely hypotheses of what we may call the metamicroscopic anatomy of the individual. The real problem of the unity and order remains not only unsolved, but its solution is placed at least beyond the present range of scientific method. Logical analysis of these theories shows clearly that their implications are fundamentally teleological and anthropomorphic. In fact so far as they are regarded as solutions of the problem they are really vitalistic theories in disguise.

In this connection let us consider for a moment the chromosome. Granting for the sake of argument the correctness of the assumptions of certain schools of scientists concerning the spatial localization of factors in particular chromosomes, it is evident that the so-called chromosome maps are nothing more than imaginary pictures of the metamicroscopic anatomy of the chromosome. If these spatially localized entities exist, they are merely anatomical characters of the organism and, as in the case of other anatomical characters, their existence, orderly arrangement and behavior remain to be accounted for. The essential problem of the unity and order of the individual is not only unsolved, but ignored, except by implication, in these hypotheses.

Concerning all the various theories of organization which in one form or another have enjoyed wide acceptance among zoologists the same objection may be made. Granting the correctness of any one of them, the postulated organization is essentially anatomical and its orderly integration remains to be accounted for. Let me make it clear that I have no quarrel with the facts along this line, so far as they are or may in the future be demonstrated to be facts. I maintain merely that they are essentially anatomical facts and as such constitute simply another step in the formulation of the real problem, not an advance toward its solution.

The rapid development within recent years of our knowledge concerning apparently specific chemical correlations between different organs or parts has led many to assert that the fundamental type of physiological correlation in the organism is of this chemical transportative character. Concerning these views I need only point out that the existence of orderly chemical correlation between parts assumes the existence and orderly arrangement of differences of some kind, in other words, of an organization of some sort. Undoubtedly chemical correlation is a factor of very great importance in determining the character of events in the organic individual, but the individual must exist as an order of some sort before orderly chemical correlation is possible. Evidently chemical correlation does not give us the solution of the problem.

The organism has often been compared to a crystal. Leaving out of consideration the fact that there is no optical or other evidence for the crystalline character of protoplasm in general, it seems to me that

these hypotheses ignore one very fundamental difference between the organism and the crystal. The unity and order of the organism are fundamentally dynamic and associated with chemical change, and when the characteristic chemical changes cease the unity and order disappear, except in so far as the anatomical record of dynamic activity may persist for a longer or shorter time. The unity and order in the crystal are static and when chemical change begins they disappear.

In this brief survey I have endeavored to bring out the fact that our biological theories of the individual, so far as they are not avowedly vitalistic or dualistic, are largely static and anatomical in fact or in implication, rather than dynamic. They are, in short, hypothetical descriptions of the machine supposed to be at work or else they tacitly assume a machine at work, but concerning the agents or processes which construct the machine and control its operation they tell us nothing. A machine which runs in a definite orderly way must be constructed according to a definite orderly plan and with the orderly employment of energy, and its operation must be controlled. In short, we must either become vitalists and admit the existence of entelechy or some other non-mechanistic principle, or else we must find some sort of dynamic unity and order as the basis of the morphological and physiological unity and order apparent to common observation. We have been trying to conceive an organic machine ready-made which shall operate in such a way as to satisfy the facts of biological observation and experiment. I believe that the essential problem is the problem of the construction and control of the organic machine. If we can gain some insight into the nature of the constructive and controlling processes we shall reach a more adequate conception of the individual than if we merely attempt to imagine a ready-made machine or individual which will satisfy the demands of observed fact. In other words, an adequate mechanistic theory of the organic individual, if such a theory is possible, must be stated in dynamic terms. It must deal primarily with processes, not structures, and with changes, not with static entities.

During the last fifteen years I have been chiefly engaged in studying and analyzing experimentally the processes of individuation in the lower animals, and this work has led me to certain conclusions concerning the nature of physiological individuality which I wish to present briefly. It has been very generally assumed by biologists that the basis of physiological individuality is inherent in protoplasm and dependent on some sort of self-determined organization. The barrenness of our theories of individuality is, I believe, the result of this view. I shall attempt to show that the physiological individual originates in the final analysis, not in a self-determined inherent organization, but in a relation between protoplasm and its environment. There are, of course, many kinds and degrees of individuality in protoplasm, both chemical and physical, such for example as atoms, molecules of the most various degrees of complexity, colloid particles, crystals, mechanical individuals such as fibrillæ resulting from strain, nuclei, cells, etc., but the integration of any or all of these into a physiological individual with a definite orderly behavior in both space and time can not conceivably be self-determined. We must either accept Driesch's entelechy or some other vitalistic principle or we must seek for the integrating factor in the relation between living protoplasm and its environment.

In what aspect of this relation can we hope to find such an integrating factor? I

believe that it exists before our very eyes in one of the most characteristic features of environmental relation, namely in spatial quantitative differences in the action of external factors on protoplasm. A brief consideration of a simple case will serve to make the point clear.

Let us begin with a mass of protoplasm, or a cell mass which is undifferentiated, *i. e.*, in which no morphological differences and no localized quantitative or qualitative differences in the metabolic reaction beyond those characteristic of protoplasm or cells in their simplest terms are present. Such a protoplasmic or cell aggregate may include individualities of various kinds, as I have already pointed out, but it is not integrated into a physiological individuality, as a whole, nor does it possess any inherent capacity for such integration.

If now such an aggregate is subjected to the differential action of environment by permitting an exciting factor, a stimulus, to act upon some point of its surface the first result is an increase in dynamic activity in the region immediately affected. It is a familiar fact of physiology that the dynamic effect of such a local excitation does not remain limited to the region directly affected by the external exciting factor. The local excitation is followed by the spreading or transmission through the protoplasm or over its limiting surfaces from the point immediately affected, of some sort of dynamic change, which itself acts as an exciting factor. For present purposes the fact of transmission, rather than the nature of the transmitted change concerns us.

Secondly, we know that in protoplasm in general such transmitted excitations decrease in energy, intensity, or in our present ignorance we may say in physiological effectiveness, with increasing distance from the point of origin, so that at a greater or less distance they become inappreciable or ineffective. This range or limit of effectiveness depends, of course, on various factors, the degree or intensity of the original excitation, the capacity of the protoplasm for transmitting excitations, etc. The case is analogous in certain respects to the spreading of a wave in water, air or any other physical medium from the point of disturbance.

Since a decrement in effectiveness occurs in transmission, the degree of excitation associated with it will be greatest at the point of origin and will decrease with increasing distance from this point. That is to say, a gradient in excitation appears in which the point of original excitation by the external factor constitutes the region of highest rate, intensity, or effectiveness. Such a dynamic gradient represents, I believe, the simplest form and the starting point of physiological integration in living protoplasm.

If the action of the external factor is of short duration this dynamic gradient usually exists for only a short time and leaves little or no appreciable persistent change in the protoplasmic substratum. If, however, the action of the external factor is sufficiently long continued or sufficiently often repeated, the protoplasmic changes sooner or later become more or less evident and more or less persistent. These changes are fundamentally changes in irritability, in the capacity of the protoplasm to react, and since these changes are in general proportional to the rate or intensity of dynamic activity in the protoplasm the dynamic gradient may produce in the protoplasm an irritability gradient. The differences in irritability at different levels are more or less persistent, and when once established tend in general to become intensified up to a certain point. In short, a dynamic or metabolic gradient arising as the result of

local excitation by an external factor may become the starting point of a persistent or permanent and primarily quantitative order in the living protoplasm, and such an order as this represents, I believe, a physiological axis or the physiological individual in its simplest form. The first order of this kind to arise in a given mass of protoplasm becomes the chief, polar, or major axis, and other similar orders established later determine minor axes, *i. e.*, the symmetry.

We now turn to the question of the nature of physiological relation or correlation in such an order as this. The fundamental relation must be one of dominance and subordination. The region of highest irritability or rate of reaction must dominate all regions of lower rate within the effective range of the excitations transmitted from it because to any stimulation of the system it reacts more rapidly or more intensely than other regions, and its greater irritability determines that it shall react to some conditions which are not effective in other regions. Consequently the excitations transmitted from this region of highest rate are more effective in determining the general metabolic rate at other levels of the gradient than the changes transmitted from any other region. The region of highest irritability or rate of reaction in such a gradient is then a physiologically dominant region, because it is the chief factor in maintaining the gradient after it is established and so in determining the general metabolic rate at each level. This dominant region of the gradient is relatively independent of other regions while they are relatively subordinate to it. In general any level of the gradient is dominated by higher levels and in the absence of these higher levels itself dominates lower levels.

The region of highest rate of reaction in the chief or major gradient becomes in development the apical region or head of the individual and a definite localization and course of development along the major axis occurs, and the localization of organs with respect to the minor gradients is also definite and characteristic. The orderly specialization and differentiation in such an individual results from the differences, primarily quantitative, which exist at different levels of the gradient.

These conclusions are based on many different lines of evidence which can be referred to only very briefly: First, a gradient in metabolic rate in which the region of highest rate becomes the apical region of the individual has been demonstrated as a characteristic feature of the major axis in animals, at least during the earlier stages of development. There is also much evidence to show that the minor axes are represented by similar gradients. The physiological individuals examined thus far include the amœba pseudopodium and various other protozoa, celenterates, flatworms, echinoderms, annelids, fishes, amphibia and birds, in all more than fifty species. Among the plants various species of axiate algæ have also been examined and a similar gradient with its region of highest rate at the apical end of the axis has been found in all. In many cases these dynamic gradients are readily distinguishable before any visible morphological differences along the axes exist.

Moreover, the very general existence of developmental gradients along the axes in both animals and plants constitutes very strong evidence for the existence of metabolic gradients, even where these have not been directly demonstrated. As regards the major axis of the animal, the so-called law of antero-posterior development is essentially a statement of the fact that morphogenic development begins or proceeds most rapidly in that region which becomes the apical or anterior end of the animal, and in

minor axes definite developmental gradients also exist. In the axiate plants essentially similar relations are found. The development of the individual proceeds from the apical end, the growing tip of the axis. In axiate organs and parts also metabolic gradients and developmental gradients correspond, so far as observation goes at present. In processes of experimental reproduction or reconstitution in pieces of the lower animals the same relations between metabolic gradients, axes and the course of development have been found to exist as in embryonic development.

Second, experimental teratogeny affords evidence of great value concerning axial metabolic gradients and even makes it possible to demonstrate their existence in certain cases where other means are technically unavailable or unsatisfactory. The method of experiment along this line depends upon the fact that the degree of susceptibility of living protoplasm to at least many, perhaps to all, agents commonly characterized as depressant or inhibitory, is very definitely related to the rate of metabolism together with the correlated protoplasmic conditions. This relation is briefly as follows: to a high intensity of action of agents and conditions, which kills without permitting the protoplasm to adapt or acclimate itself, the susceptibility varies in general directly with general metabolic rate. The higher the rate the earlier death occurs, and *vice versa*. To a low intensity of action which permits the protoplasm to adapt or acclimate itself to some extent, the susceptibility in the long run varies in general inversely with the metabolic rate, because, the higher the rate, the greater the capacity for, and rate of acclimation. We see these relations more or less clearly in the susceptibility of young and old organisms to various external conditions. To extreme conditions the young with their higher metabolic rate are more susceptible than the old. Medical practise in the administration of drugs to children and adults recognizes this difference in susceptibility, though so far as I know it has never been formulated in general terms. On the other hand, the young organism adapts or acclimates itself more readily and rapidly than the old to conditions which are not too extreme to permit acclimation. There is a large body of evidence in support of these conclusions concerning susceptibility which can not be considered here.

The point to which I wish to call attention is the relation between susceptibility and metabolic rate on the one hand and developmental control and experimental teratogeny on the other. If the major axis of the animal egg, or embryo, is primarily a metabolic gradient with the highest rate in the apical region, we should expect this gradient to appear as a susceptibility gradient to various external factors. This I have found to be the case. By subjecting, for example, the unfertilized egg or the embryo of the sea urchin in various early stages to rather extreme action of various agents and conditions it is possible to obtain a gradient in inhibition of development in which the apical region is most inhibited, the basal least. On the other hand, with agents or conditions whose action permits some degree of adaptation or acclimation, the apical region, though at first most inhibited, is in the long run least inhibited, the basal most, because the apical region possesses greater capacity for acclimation than the basal. By this means two opposite types of teratological larvæ are obtained, the one with apical region most inhibited and therefore disproportionately small and retarded in development, the other with the apical region least inhibited and therefore disproportionately large and advanced in development. Between the two ends of the axis the degree of

inhibition differs with the level in the gradient. Similar differences in degree of inhibition along the axes of symmetry are also present in such cases. In this way the whole shape, proportions, and degree of development of different parts can be modified and controlled to a high degree and in two opposite directions. Similar results have been obtained with other forms. Moreover, at least most cases of experimental teratogeny resulting from the action of chemical agents and general environmental conditions, as well as many teratological forms observed in nature can be readily interpreted on this basis. Experimental teratogeny then affords, on the one hand, a valuable check on other means for demonstrating axial gradients, and, on the other, finds a simple interpretation, at least as regards many of its features, on the basis of the general conception of metabolic gradients.

Third, it is possible in some of the lower animals to eliminate the original axes in isolated pieces by means of narcotics, and then to establish a new axis in a different direction by subjecting the pieces to a gradient in external conditions. The shorter the piece, the less marked the original polarity and the more readily new polarities arise in response to the differential action of external factors. Very short fractions of the axis may be completely apolar in their behavior. This fact indicates that physiological polarity is not, as often assumed, a property of the protoplasmic molecule, but rather a function of protoplasmic mass, as it must be if it is fundamentally a metabolic gradient.

Fourth, it has been possible to demonstrate experimentally for certain of the lower animals that a relation of dominance and subordination exists along the major axis. The apical region dominates all other levels of lower metabolic rate within the range of its influence, and in the absence of the apical region the highest level of the gradient present dominates all levels below it and within its range. The apical region itself, however, is to a high degree independent of other levels of the axis. In the reconstitution of pieces it is capable of developing, at least to a very advanced stage, and in the lower animals, apparently completely in the entire absence of other parts. The development of hydranths or apical portions of hydranths from short pieces of *Tubularia* stem, which has been described by various authors, is an example. Other levels of the body, however, never arise in reconstitution except in connection with more apical or anterior levels, though an apical end need not be present to determine their formation. In axiate plants the relations are essentially identical as regards the major axis. The dominance of the apical region, the growing tip of plants, over other levels has long been recognized by botanists. Moreover, in plants the apical region may arise in the absence of other parts, and the development of other parts takes place basipetally from it.

In the experimental reproduction of various simple animals, I have found that when the metabolic rate in the apical region is decreased, organs along the axis arise nearer to the apical end and to each other, while increase in metabolic rate of the apical region determines their localization farther away from it and from each other. If the localization of these organs is determined by a certain position in the axial gradient this relation between localization and metabolic rate in the apical region is easy to understand, for when the rate is low the gradient is shorter and the dynamic conditions for a particular organ arise nearer the apical end, while a high metabolic rate means a longer metabolic gradient and the

localization of these conditions at a greater distance.

The relation of the central nervous system to the axial metabolic gradients is a point of particular interest. The apical or cephalic part of the nervous system develops from the apical region of the major axis which is, at least primarily, the region of highest rate in the whole body and the postcephalic portions develop in or near the region of highest rate in the symmetry gradients, the median ventral region in the bilateral invertebrates, the median dorsal region in the vertebrates.

If the organic individual consists primarily of a number of qualitatively different entities between which chemical transportative correlation exists, it is difficult to understand why it should transform itself during development into an individual which is dominated by a nervous system, in which transmitted changes instead of transported substances are the means of correlation. From this point of view the nervous system seems to arise from nowhere and out of nothing as an added superior system which integrates the previously existing mosaic of entities or qualities into an individual. From the dynamic viewpoint, according to which a physiological axis is primarily a metabolic gradient, the appearance, localization, course of development and functional dominance of the central nervous system are the natural and necessary consequences of the relations of dominance and subordination which have existed in the axial gradients from the beginning. The central nervous system is in fact merely the final morphological and physiological expression of dynamic relations which constitute the first step in individuation.

Brief mention of some other cases of functional dominance in relation to metabolic gradients is perhaps of interest. Mayer has shown that in the medusa *Cassiopea* that particular one of the marginal nerve centers which has the most rapid rhythm initiates the wave of muscular contraction and for the time being sets the pace for the others. Dominance here is of course only temporary. In the vertebrate heart the sinus region is dominant and initiates the beat. Dr. Hyman has been able to demonstrate that in the tubular embryonic heart an axial metabolic gradient exists and the region of highest rate in this gradient develops into the sinus. Tashiro has recently shown that a metabolic gradient exists in the neuron and that conduction of impulses is normally down this gradient.

Fifth, the localization of, and the conditions determining, various processes of agamic reproduction of new individuals from parts of those previously existing afford valuable evidence in support of the dynamic conception of the individual. Since the transmitted changes in protoplasm undergo a decrement in effectiveness with increasing distance from the point of origin, their range of effectiveness, in other words the range of dominance, is spatially limited. This range may vary with different conditions, metabolic rate in the dominant region, intensity of transmitted excitation, conductivity of protoplasm, interference with other transmitted excitations, etc. The range of dominance in a particular axis in a specific protoplasm under given conditions represents the physiological maximum of size which the individual can attain in that dimension under those conditions and remain physiologically an individual. Any part which comes for any reason to lie outside the range of dominance is thereby physiologically isolated and no longer physiologically a part of the individual. In most plants and lower animals such physiological isolation of a part, like physical isolation, is usually followed by

more or less dedifferentiation and rejuvenescence and then by reproduction of a new individual. In agamic reproduction in general such physiological isolation is a fundamental factor. Physiological isolation may occur in consequence of continued growth in size or length of the body to such an extent that some part becomes physiologically isolated. Second, it may also occur in consequence of decrease in metabolic rate in the dominant region, thus decreasing the range of dominance, until finally the limit of dominance is less than the length of body along the axis concerned. Third, physiological isolation may also result from a decrease in conductivity in the path of transmission, thus decreasing the range of effectiveness of the transmitted excitation, or in extreme cases blocking it. And finally, physiological isolation may result from the local action of an exciting factor on a subordinate part, increasing its metabolic rate to such an extent that it becomes independent of, or insusceptible to the dynamic changes transmitted from the dominant region. The best proof of the correctness and adequacy of this conception lies in the fact that experimental determination and control of physiological isolation and reproduction are possible, either in plants or animals, in all these ways. To mention only one case, in many plants and in various simple animals we can induce agamic reproduction, not only by inducing growth in size, but by inhibiting or removing the apical dominant region.

In order that the physiologically isolated part may give rise to a new individual it must either retain to some degree in its protoplasm the axial gradient or gradients determined in it while it was still physiologically a part of the parent individual, or else new gradients must be determined in it by the differential action of external factors. We find both these possibilities realized in nature and in experiment. In short, the phenomena of agamic reproduction in both plants and animals afford very strong evidence in support of this conception of the organic individual.

Gametic reproduction differs from agamic, first, in that the gametes are more highly differentiated, physiologically older cells than those concerned in agamic reproduction and require in most cases the special conditions of fertilization to initiate the process of reproduction and rejuvenescence; second, in that the isolation of these cells from the parent body in multicellular forms is not directly connected with the range of dominance in the individual, but seems to be rather a process of elimination or extrusion of cells which, so far as the parent body is concerned, have completed their life-cycle, are approaching death and have no further rôle to play as physiological parts of the body and are got rid of like other inactive waste material.

One or two other points require brief consideration. I have endeavored to make it clear that the physiological integration of protoplasmic parts or of cells into an individual with a definite characteristic orderly behavior in space and time is not self-determined by some sort of organization inherent in the protoplasm, nor by some non-mechanistic integrating principle such as Driesch's entelechy, but in the final analysis by the relation of the protoplasm or cells concerned to the environment, primarily the external environment, though in the individuation of parts of an organism the intra-individual environment may be the effective factor. In fact, physiological individuality is fundamentally the result of interrelation between living protoplasm and its environment. The fact that morphological and physiological order in development and evolution are primarily superficial, as for example in the protozoa and in most

plant cells where only the superficial layers of the protoplasm show a definite persistent morphology receives a simple interpretation from this point of view, while from any other standpoint it is difficult to find a reason for this superficial appearance of order. The superficial origin of the nervous system in development is perhaps the most notable case in point.

It is not necessary, however, to assume that every organic individual arises directly through the differential action of environmental factors. When the metabolic gradients with their associated protoplasmic conditions are once determined in a mass of protoplasm or cells they or their protoplasmic substratum may persist for many generations through division or other reproductive processes. In other cases factors in the intra-individual environment may determine the gradient or gradients in certain parts. The polarity of the egg, for example, shows in most cases in both animals and plants a definite relation to the point of attachment of the growing egg cell to the parent body, and there is good reason to believe that the differential action of the egg's environment in the organism determines its polarity. In some cases, however, this polarity, if present, is apparently eliminated and a new polarity established by external factors acting after isolation, as for example in the egg of the alga *Fucus*, where the axis of the egg and so of the plant is apparently determined by incident light, or in its absence by other differential relations to external conditions. Evidently a physiological axis may be inherited through one or more generations after it is once established, or it may be determined *de novo* in each reproduction. Experiment demonstrates that even in many cases where it is inherited in nature we can eliminate it and determine the establishment of a new axis by the differential action of external conditions.

Considering for a moment another point, the question may be raised whether a mere gradient in rate of metabolism with its correlate of protoplasmic condition is adequate to account for the differentiation that arises along an axis in development. To those who have been accustomed to postulate a great number of qualitatively different entities as the starting point of the organic individual such a conception may seem to be almost ridiculously inadequate. The facts, however, are these. We can produce experimentally morphological differences which are clearly qualitative through the action of external factors, such, for example, as temperature, which act on metabolism primarily in a purely quantitative way. Moreover, it is clear from various lines of evidence that the character of the substances which accumulate in a particular protoplasm as components of its structural substratum is very closely associated with metabolic rate. When the rate is high only certain substances produced in the course of the metabolic reactions and which are relatively stable under these conditions can accumulate as a structural substratum, while other substances are broken down and eliminated. With a lower metabolic rate some of these other substances do not break down so readily and therefore they also may accumulate and so on. Take the simple case of the accumulation of fat in a cell. We know that a low metabolic rate favors fat accumulation and a higher rate may lead to its disappearance. But we can not doubt that after the accumulation of fat in a cell has begun, the presence of the fat alters the metabolic processes occurring in that cell: its appearance in the cell is associated with a certain metabolic rate, but once present it may alter not merely the rate, but the kind of metabolism which occurs. Various factors indicate also that differ-

ences in metabolic rate may determine the production of different substances. On the basis of these and other lines of evidence, I believe that we are fully justified in maintaining that purely quantitative dynamic differences, *i. e.*, differences in metabolic rate may and do serve as the starting point of very great qualitative differences, both in structural constitution and character of metabolic reaction. In short, both physiological and biochemical facts support the view that a metabolic gradient is adequate to account for the beginning of differentiation along a physiological axis, and the burden of proof must rest on those who maintain that it is not. Of course the character of the qualitative differences which arise from the quantitative, must depend on the specific constitution of the protoplasm concerned.

It is evident that as soon as orderly differences arise chemical transportative correlation between the different parts must play a very important rôle in determining the character and course of further developmental changes, but it is also evident that such chemical correlation can not exist until differences exist nor can it be orderly or definite in character unless the differences on which its existence depends are orderly and definite. The conception which I have presented is an attempt to show how these orderly differences arise and make possible chemical correlation.

To sum up, physiological individuality depends fundamentally and from the beginning on the transmission of dynamic excitations and not upon the transportation of substances. Transportative correlation, while of great importance, is a secondary factor, playing a rôle in determining the course and character of development, but not in determining the existence of an individuality. And, furthermore, the facts indicate that a definite orderly transmissive correlation can originate only in a region of relatively high metabolic rate determined in the final analysis by factors external to the protoplasm concerned. Transmission from such a region of high rate determines a metabolic gradient together with its protoplasmic correlates, and so constitutes a physiological axis, a physiological individuality in its simplest form.

In conclusion I wish to point out the fundamental similarity from this point of view between the physiological and the social individual. The organism has often been compared to an ordered community of human beings or a state, but in these comparisons the question as to the factor or factors which determine the orderly character of the organism has usually been ignored. In the social individual it is authority or government which integrates the human units into an orderly whole. I have attempted to show that an authority or government of a simple dynamic kind is the primary integrating factor in the physiological individual. There are, moreover, certain rather fundamental similarities which are more than far-fetched fanciful analogies between government in the organism and in the social individual.

In its simple primitive forms, such as tribe, clan, etc., the social individual is integrated by the authority of a dominant person or perhaps of a group and this authority consists fundamentally in what we call brute force, which is something not very different from high metabolic rate in the organism. The dominance of the ruling personality depends, not upon the transportation of material from him to other members of the community, but upon the transmission of personal influence, and the size of the primitive social individual depends on the extent to which he is able to make this influence felt, *i. e.*, on his per-

sonal authority, the degree of his dominance and the means available for its transmission. The border regions of this social individual are but little under his influence and may become physiologically isolated in the same way that parts of the organism become physiologically isolated, either by growth in size of the whole so that the dominant personality can not longer control the outlying portions, by a decrease in his dominance as the result of advancing age, illness or other conditions, by obstacles to transmission of his authority, or finally in consequence of local conditions which make the particular group of persons more or less independent of or less receptive to the original authority. As in the organism, any of these conditions may result in the reproduction of a new orderly individuality like the old or different from it according to the character of the isolated group and the environmental conditions. The only condition necessary for this sort of reproduction in the physiologically isolated part of the social individual is the existence or development of a new dominant personality and neither an isolated part of an organism nor a group of human beings can exist for any great length of time in a natural environment without the appearance of differences of this sort between component parts.

I have maintained that the orderly physiological individual can not arise on a basis of chemical transportative correlation and we can see very readily that the state can not arise on a basis of barter and exchange or commerce. When once different individualities are established the character of material exchange may be an important factor in determining their further course of development, but the social individual originates in authority and its transmission, not in the exchange of substance.

The evolutionary development and differentiation of the social individual also parallels the evolutionary and individual development of the animal organisms. Specialization and differentiation of different parts occur as the result of local commercial or other conditions, and the means of transmission and transportation also develop, so that the physiological limit of size increases to an indefinite degree and physiological isolation of parts is much less likely to occur. The governmental authority and the means for its transmission develop into a complex machine comparable to the nervous system of the animal.

In fact we can even find a parallel in the organism to the approach toward democracy with advancing evolution of the state. The simple organism and the earlier stages of development of the higher forms are fundamentally of the primitive monarchical type. The dominant region is wholly or to a large extent independent of other parts, but dominates them. As organic evolution and development proceed, however, we find sooner or later that the development of the dominant region, the cephalic central nervous system, begins to be influenced by subordinate parts. This influence may result either from transmission or transportation. In certain reflexes in the higher organisms there is something very similar to the delegation of authority by the people to the government. We might say that in the evolution and development of the organism as in that of the state, government becomes more and more a representative government.

These similarities, I am tempted to say these fundamental identities, between the physiological and the social individual are based on the fundamental nature of living things. This close parallelism between those two dynamic individualities seems to me to constitute in itself evidence of great importance for the conception of the physi-

ological individual which I have tried to present.

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THE BASIS OF INDIVIDUALITY IN ORGANISMS FROM THE STANDPOINT OF CYTOLOGY AND EMBRYOLOGY[1]

I

AN individual in the broadest sense is any animate or inanimate thing which is regarded as a unit. In this sense the electron, atom, molecule, crystal, biophore, determiner, chromomere, chromosome, nucleus, centrosome, cell, organ, system, person, corm, state, species, etc., are individuals. In all but the simplest units individuality involves organization, that is differentiation into parts and integration into a single whole. A fundamental property of any unit is its separateness or separableness, from other units, and yet no unit is completely independent. Biological units are separate in both structure and function from other units and yet they are related to others and these relations may be of such a sort that they constitute units of a higher order. Organic individuality of whatever order is dependent upon separateness of structure, of growth and of division. But while all vital units are separate or separable, they vary greatly in independence from the parts of a cell which are incapable of independent life to cells and to persons which are capable by themselves of maintaining life processes. The failure to distinguish between separateness and independence has been a fruitful source of misunderstandings in biological controversies.

[1] Read at a joint symposium of the American Society of Zoologists and Section F of the American Association for the Advancement of Science, Columbus, Ohio, December 30, 1915.

An organic individual then is any unit capable of manifesting the properties of life. The simplest and most fundamental properties of life are: (1) Metabolism, especially assimilation and growth, and (2) Reproduction by division. Every vital unit manifests both of these properties from the ultra-microscopical units of living matter to its more complex aggregates. To these two properties there is usually if not invariably added (3) sensitivity or the capacity of responding to stimuli, frequently in a beneficial or adaptive way. An organic individual then is capable of assimilation, growth and division and it may be irritable or sensitive. This definition can not be made more specific, for individuality is not a hard and fast thing. There are all degrees of organic individuality from the simplest and smallest units of living matter to the largest and most complex. As applied to human beings and their organization into society, the word "individuality" has come to have a metaphysical and mystical significance and not infrequently this mysticism has been extended to all forms of individuality.

1. *Individuality of Ultra-microscopic Units of Living Matter.*—Long ago Brücke (1861) maintained that protoplasm must be composed of ultra-microscopic units capable of assimilation, growth and division and these units he called "the smallest living parts." Many students of the subject since that time have postulated similar units; such as the "physiological units" of Spencer, the "gemmules" of Darwin, the "plasomes" of Wiesner, the "pangenes" of de Vries, the "idioblasts" of O. Hertwig, the "biophores" and "determinants" of Weismann, and the "factors," "determiners" and "genes" of many students of heredity. Recent studies of Men-

delian inheritance have furnished an extraordinarily complete demonstration of the existence of such inheritance units and of their persistence generation after generation. Such units are individuals in that they are separate from, though dependent upon, other units and in that they apparently manifest the fundamental vital processes of assimilation, growth and division.

2. *The Individuality of Parts of Cells.*—Many parts of a cell, such as the chromomeres, chromosomes, plastids, and in some instances at least, the centrosomes and plastosomes are also individuals in this same sense. The question of the individuality of chromosomes and centrosomes has given rise to much controversy chiefly because the term "individual" has not been clearly defined. No one doubts that chromosomes have the power of assimilation, growth and division and the only question at issue is as to whether they disintegrate at the close of every division and are formed anew at the beginning of the succeeding division. Now that individual chromosomes have been traced right through the entire resting period in several cases, there is no longer any reason to doubt that chromosomes do in some instances preserve their individuality. The fact that they, like all other forms of living matter, undergo metabolic change, receiving food substances on the one hand, and building them up into their own substance, and on the other hand, giving off the waste products of their own destructive metabolism—in short that the materials of which they are composed are undergoing continual change—does not obscure the individuality of a chromosome any more than a similar process obscures the individuality of a man. That which persists amid all metabolic changes in both the chromosome and the man is not identical atoms or molecules, but an identical organization or plan or relation of subordinate parts to one another.

In my experience the same is true of centrosomes; they also undergo growth and division, are continuous from cell generation to cell generation, and do not arise *de novo* from "cytasters," which are only temporarily isolated portions of archiplasm or kinoplasm, though they are genetically related to achromatic constituents of the nucleus. In all probabilities there are other units in the cell which preserve a like individuality, as, for example, plastids and plastosomes. All such parts of a cell have an individuality of their own, in that they are separate though not independent, and have the properties of assimilation, growth and division.

3. *Individuality of Cells.*—The individuality of ultra-microscopic units and of visible parts of cells is of a different order from that of entire cells. The former, though separate, are yet so dependent on other units as to be incapable of independent existence. In the cell for the first time we find an organic individual sufficiently independent to carry on by itself all fundamental processes of life. Protista, germ cells, embryonic cells and tissue cells show this independence in varying degrees, and yet of course, no cell and no higher organism is absolutely independent of other organisms or of the environment. In short, independence is a relative term and is no necessary part of individuality.

In the union of the egg and sperm cells in fertilization, the cells lose their independence as cells, though the separateness of parts of these cells may persist. There is here the merging of two cell individualities into one, just as in the reverse process of cell division there is the merging of one cell individuality into two. But so far as

separateness and independence are concerned, the fertilized egg cell or oosperm, and the fully formed organism into which it develops are one and the same individual, though differing greatly in complexity. This fertilized egg fuses with no other cells, it takes into itself no ready-made living substance, but manufactures its own protoplasm from food substances; it carries on its own processes of assimilation, growth and division—in short it is a separate and highly independent living thing which may be designated as an organism.

The complexity of any individual is proportional to the number of *unlike units* which constitute it, and this is as true of a chromosome as it is of a person. A common mistake is the supposition that complexity is determined by the *number* of cells, whether like or unlike, composing a body. On the other hand, as Whitman showed, the body of a one-celled protozoan may be as complex as that of a many-celled metazoan; and every zoologist knows that a mouse is as complex as an elephant, though it is composed of a much smaller number of cells. In the development of an egg cell the complexity of the entire individual increases only as the number of unlike parts increases; mere duplication of like parts leads to increase in size, but not to increase in complexity.

Only in relatively simple units is division non-differential so that both products are entirely alike, as is probably the case in all ultra-microscopic units, in cell organs and in very simple cells. In more complex individuals, whether they are cells or cell aggregates, the products of division usually differ from one another, at least when first formed, and in the most complex individuals division of the entire organism is more or less completely abandoned. In the division of a protozoan like *Paramecium* the two products are at first unlike, but as they continue to separate they become alike by a process of regulation. If these products of fission did not separate and did not undergo regulation, there would be formed a number of cells, organically connected and differing from one another in structure and function. This is just what happens in the cleavage of the egg of a metazoan; the original organism divides into many cells each of which is more or less dependent upon others. The original individual is broken up into many parts, but it is evident that there is one individual of the grade which may be called an organism at the beginning of development and just one and no more at its end; indeed the organism is the same individual from the oosperm to the end of life, irrespective of the number of cells or subordinate parts of which it may be composed. However, if cleavage cells separate and undergo regulation, as in the case of *Paramecium*, we may have as many organisms as there are separate parts. This applies to the division of groups of cells or body parts as well as to cleavage cells. If cells or parts of cells separate off which are not capable of regulation and of continued life, they do not form independent individuals.

II

If now we inquire what causes an individual of any grade to divide and thus to give rise to two new individuals we are compelled to confess that we do not know in any instance. The cause of the division of a centrosome or chromosome or nucleus or cell is as mysterious as the cause of division of a hydroid or worm. The division of the cell has been studied more fully than that of any other individual. We know that the centrosome divides before the nucleus and the latter before the cell body, but while we know that a cause must precede its effect we can not say *post hoc*

ergo propter hoc. The fact is we do not know what causes the division of a centrosome, or chromosome or cell or a many-celled organism.

Spencer held that since the volume of any organic body increases as the cube of its diameter, whereas its surface, through which it must receive nutriment, increases only as the square, it must divide after reaching maximum size in order to restore a proper ratio of surface to volume; but although this may be true in general, the sizes of cells, or of other organic bodies, vary enormously and it does not seem possible to explain all these differences in size in accordance with Spencer's hypothesis alone; furthermore, there is no indication of the mechanism by which this general need to divide actually causes division. Boveri assumed that chromosomes and nuclei grow until they are equal in size to the parent structures from which they came and that they then divide; but this is far from being true in some cases. In the cleavage of the egg the cells, nuclei, chromosomes and centrosomes progressively grow smaller, and this not at any uniform rate for all cells, some growing smaller much more rapidly than others. R. Hertwig finds the cause of cell division in the preservation of a proper ratio between the nuclear volume and the cell volume, but as I have shown there is no contant nucleus-plasma ratio since this ratio differs greatly even in different cells of the same embryo. Strassburger held that the cause of cell division was to be found in the limit of the "working sphere of the nucleus," and that when in the growth of the cell this limit was reached, the cell divided; but again it may be objected that there is no fixed limit to the "working sphere of the nucleus" even in the same animal; in some cells of *Crepidula* the volume of the nucleus at the time of division is three times that of the cytoplasm, in others the cytoplasm is fifteen times that of the nucleus. Apparently no single one of these factors is the determining cause of cell division, and it seems probable that the latter is brought on by the coincidence of several more or less independent factors.

In a series of contributions and in two recent books Child has emphasized the importance of polar "gradients of metabolism" as the basis of organic individuality. He finds, for example, that metabolism is most active at the anterior or head ends of certain protozoa, hydroids, flatworms, embryos, etc., and that it becomes less active toward the opposite ends. Regions of higher activity "dominate" those of lower activity, and whenever the metabolic activity of the head region ceases to dominate the entire body, secondary regions of higher metabolic activity appear and may lead to division, one individual thus becoming two; the basis of individuality is thus reduced to polar gradients in metabolism. But in existing organisms physiological gradients are associated with corresponding gradients in material structure, since structure and function are inseparable in living things. Disembodied functions are as unknown in biology as are disembodied spirits. Doubtless gradients of metabolism as well as of growth, division, differentiation and sensitivity exist in organisms; but there is good reason to maintain that such gradients in physiological processes are associated with corresponding gradients in material substances, and this is merely to hold that axial differentiations, both physiological and morphological, exist in organisms. That such differentiations frequently accompany the division of cells or of multicellular organisms is well known, but that they cause these divisions is unproved. The simplest individuals, such as chromo-

meres, chromosomes and centrosomes, divide into approximately equivalent halves; in many cells and cell aggregates the division halves are not equivalent, though they may later become so by regulation. It seems probable that, apart from this difference, the causes of division of all grades of individuals, from the simplest to the most complex, will be found to be similar. Individuals capable of independent existence arise either by equivalent division, as in bacteria, ameba and the germ cells of many-celled organisms, where subsequent regulation is slight, or by non-equivalent division followed by a large amount of regulation, as in the fission of many higher protozoa and metazoa. The basis of individuality in the one case is division with slight regulation, in the other division and considerable regulation.

Individuals, therefore, come into existence by the division of previously existing individuals, though it is conceivable that they may also be formed anew by the synthesis of smaller units; the former is what is known as *biogenesis*, the latter *abiogenesis*. Likewise individuals go out of existence by the division of one individual into two, with consequent loss of the original individuality, that is in reproduction, and also by the disintegration of an individual into its constituent units, namely in death.

EDWIN G. CONKLIN
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RESOLUTIONS IN MEMORY OF RUDOLPH AUGUST WITTHAUS AND CHARLES CLIFFORD BARROWS

THE faculty of the Cornell University Medical College has adopted memorials on the deaths of two of its members, Professor Witthaus and Professor Barrows. The memorials, which were drawn up by Warren Coleman, W. Gilman Thompson and W. M. Polk, are as follows:

In the death of Dr. Rudolph August Witthaus, emeritus professor of chemistry, on December 19, 1915, after a long illness, the medical faculty of Cornell University sustained the loss of one of its most famous men.

Dr. Witthaus was graduated from Columbia University in 1867 and received his Master's degree in 1870. He continued his studies at the Sorbonne and the Collège of France. In 1875 he obtained the degree of M.D. from the University Medical College (New York University). He occupied chairs of chemistry and toxicology, chemistry and physiology, and chemistry and physics in the universities of Vermont, Buffalo and the University Medical College (New York University). In 1898 he was called to the chair of chemistry and toxicology in Cornell University Medical College and occupied this position until his retirement, for age, in 1911. Since 1911, he had been emeritus professor of chemistry in Cornell University Medical College.

Dr. Witthaus's career was most notable perhaps for two circumstances, the eminence to which he rose and for the fact that the subject in which he acquired fame was, in his youth, the plaything of a dilettante. His interest in chemistry dated back to his college days when he converted a room in his father's stable into a laboratory where he amused himself with the study of chemical problems. Reverses in fortune soon compelled him to seek a livelihood in what had been his hobby.

In his riper years he was without a peer as a medico-legal expert. His services were often sought by the state in criminal trials involving toxicological questions and his testimony was always an important, if not the leading factor, in the verdicts of the juries. He made what is probably the most complete catalogue of reported cases of poisoning in existence.

Dr. Witthaus was a prolific, as well as a convincing, writer. His text books, "Essentials of Chemistry," "General Medical Chemistry," "Manual of Chemistry" and "Laboratory Guide in Urine Analysis and Toxicology," were much in demand and passed through numerous editions. He contributed articles on toxicological subjects to Wood's "Handbook of the Medical Sciences," and edited "Witthaus and Becker's Medical Jurisprudence" the fourth volume of which he wrote.

He was a Fellow of the American Association for the Advancement of Science and the Academy

of Medicine and other scientific bodies, including chemical societies in Paris and Berlin.

Dr. Witthaus was a man of broad culture and had many interests outside of his profession. He was an ardent disciple of Izaak Walton. His love of books amounted to a passion. At several different periods of his life he collected libraries of first and other rare editions. During his last years his chief interest lay in the collection and cataloguing of books and original manuscripts.

His fortune and medical library were bequeathed to the New York Academy of Medicine.

The faculty of Cornell University Medical College records with sorrow the death of their colleague, Dr. Charles C. Barrows, assistant professor of gynecology, which occurred on January 2, 1916, after an illness of two months.

Dr. Barrows's association with the Cornell University Medical College dates from the foundation of the college in 1898, when he was appointed clinical instructor in gynecology. He occupied this position until his promotion to the assistant professorship of gynecology in 1912. At the time of his death he had been nominated for the professorship of gynecology and he had already assumed charge of the department. The greater portion of Dr. Barrows's teaching consisted of clinical demonstrations and operations in Bellevue Hospital. Following the recent trend in medical education he introduced the system of clinical clerkships into the teaching of gynecology. Dr. Barrows was a successful as well as a popular teacher. Through his ability he excited the admiration of his students and stimulated them to put forth their best efforts; through his kindliness he made them his friends.

Except for a brief period while serving in the army, Dr. Barrows has been connected with Bellevue Hospital since 1880, when he won his appointment as interne. After his return to New York he was appointed assistant visiting gynecologist, holding this position until he became visiting gynecologist in 1915. Many of the finest traits of his character appeared in his hospital relations. He was renowned not only for his skill as diagnostician and surgeon but for his patience and poise under the most difficult circumstances. He was considerate of his subordinates at all times. No patient was too poor to claim his attention. He carried hope and encouragement to every bedside and through his skill restored many a sufferer to health and usefulness. A recent graduate of the hospital, when asked to voice the strongest impression which Dr. Barrows had made upon him, replied, "his heart was as big as the man." The loyalty of the internes serving under him was especially notable. They never speak of him except in terms of affection, and friendships formed during their hospital days grew stronger as the years advanced.

Dr. Barrows was widely known as one of New York's most skillful surgeons, and for years he enjoyed a large and successful practise. He was a member of many medical societies, was a frequent contributor to medical literature on subjects pertaining to his specialty, and devised important new surgical procedures.

SCIENTIFIC NOTES AND NEWS

On the seventieth birthday of the distinguished Swedish mathematician, Professor M. G. Mittag-Leffler, he and his wife set aside their entire fortune for the foundation of an International Institute for pure mathematics.

The Willard Gibbs Medal, founded by William A. Converse, of Chicago, has been awarded to Dr. Willis R. Whitney, director of the research laboratories of the General Electric Company, Schenectady, N. Y. The presentation will be made on May 19, in connection with the meeting of the Chicago Section of the American Chemical Society, when Dr. Whitney will make an address on "Incidents of Applied Research."

Students of pharmacy in the University of Pittsburgh have given a dinner in honor of Dean J. A. Koch, who has been in his present position for twenty-five years.

Mr. Henry W. Fowler has been elected president of the Delaware Valley Ornithological Club.

Sir Richard A. S. Redmayne has been elected president of the British Institution of Mining and Metallurgy in succession to Sir Thomas K. Rose.

At the twenty-first annual meeting of the Michigan Academy of Science held in Ann Arbor on March 28, 29 and 30, officers were elected as follows: *President,* Wm. H. Hobbs; *Vice-presidents,* Zoology, R. W. Hegner, University of Michigan; Botany, G. H. Coons, Michigan Agricultural College; Geology, L. P.

Barrett, Michigan Geological and Natural History Survey; Economics, F. A. Carlton, Albion College; Sanitary and Medical Science, H. W. Emerson, Pasteur Institute; *Secretary and Treasurer,* Richard de Zeeuw, Michigan Agricultural College; *Editor,* R. A. Smith, Michigan Geological and Natural History Survey; *Librarian,* Crystal Thompson, Museum of Zoology, University of Michigan.

WE learn from *Nature* that Second Lieutenant G. I. Taylor has been appointed to the temporary rank of major in the British Royal Flying Corps, while performing the duties of professor of meteorology. Major Taylor is a fellow of Trinity College, Cambridge, to whom the Adams prize was recently awarded. Up to the outbreak of war he held the Schuster readership of the Meteorological Office at the University of Cambridge. The professorship of meteorology to which Major Taylor is appointed is a new establishment, for which the meteorological office is responsible, for instruction and special researches in the structure of the atmosphere in the interest of the Royal Flying Corps.

SIR THOMAS H. HOLLAND, F.R.S., professor of geology and mineralogy in the University of Manchester, has been appointed chairman of a commission which the British government is forming to survey the economic resources and industrial possibilities of India.

DR. RAYMOND F. BACON, director of the Mellon Institute for Industrial Research of the University of Pittsburgh, has been appointed by the secretary of the navy as an associate member of the Naval Consulting Board and a director on the board of organization for industrial preparedness in Pennsylvania.

E. C. BINGHAM, Ph.D. (Johns Hopkins, '05), who for the past few years has been professor of chemistry in Richmond College, Richmond, Virginia, is spending the year 1915–16 in the Bureau of Standards, Washington, D. C.

CHESTER W. WASHBURNE, formerly with the United States Geological Survey, has returned to the United States after two years in the Belgian Congo where he went to prospect for oil.

THE scientific staff of the biological station of the University of Michigan, at Douglas Lake, Michigan, has been completed as follows: Director, O. C. Glaser; ornithology, R. M. Strong; vertebrate zoology and entomology, M. M. Ellis; parasitology, W. W. Cort; plant ecology, F. C. Gates; systematic botany, J. H. Ehlers; field and forest botany, R. M. Holman; assistants, R. M. Hall, M. Reynolds and C. B. Cotner.

THE Mellon Institute of the University of Pittsburgh will exchange services between its department of research in pure chemistry and the graduate departments of chemistry in other universities. Professor M. A. Rosanoff will lecture for a week at each of the other universities while a representative from that institution lectures at the Mellon Institute. Professor Harkins, of the University of Chicago, and Professor Washburn, of the University of Illinois, have arranged to go to Mellon Institute, and Professor Bogert, of Columbia University, will probably lecture at the institute later in the year.

DR. WILLIAM H. WELCH, of the Johns Hopkins University, delivered a lecture before the Book and Journal Club of the Medical and Chirurgical Faculty of Medicine, March 22, on "The Development of Medicine in the Orient."

PROFESSOR JOSEPH JASTROW, of the University of Wisconsin, addressed the Sigma Xi Society of the University of Indiana on March 28 on "The Expression of the Emotions," and delivered the Convocation address at that university on March 29 on "Theory and Practise." On March 29, he gave the Sigma Xi address at Purdue University on "The Sources of Human Nature."

PROFESSOR A. W. GOODSPEED, director of the Randal Morgan Laboratory of Physics, University of Pennsylvania, gave a series of three illustrated lectures at the Brooklyn Institute of Arts and Sciences on the X-rays on the evenings of February 25, March 3 and 10.

Dr. Harry Clary Jones, professor of chemistry in the Johns Hopkins University, died at his home in Baltimore on April 9, aged fifty-one years.

Professor Wells Woodbridge Cooke, assistant biologist of the biological survey of the Department of Agriculture, and one of the leading authorities of the United States on bird migration and distribution, died from pneumonia on March 29, aged fifty-eight years.

Frederick C. Ohm, of the petrographic division of the United States Geological Survey, died in Washington, on March 14, aged fifty-eight years.

Dr. Nathan Oppenheim, the author of several books and numerous articles on the development, the hygiene, and the diseases of the growing child, died in New York City, on April 5, aged fifty-one years.

Dr. Theodore Bernard Sachs, one of the leading workers in the antituberculosis campaign in the United States and until a few days ago superintendent of the Municipal Tuberculosis Sanatorium, Chicago, committed suicide on April 2, at the age of forty-eight years.

Mr. Geoffrey Meade-Waldo, of the entomological department of the British Museum, died on March 11, after a short illness. Mr. Meade-Waldo was the author of numerous important papers on Hymenoptera, and at the time of his death had just completed the arrangement of the bees in the museum.

Sir Alexander Russell Simpson, formerly dean of the faculty of medicine of the University of Edinburgh, died on April 6, at the age of eighty-one years.

Sir Charles Ball, regius professor of surgery in the University of Dublin, died on March 17, aged sixty-five years.

Lady Kelvin died on March 16, having survived by nine years Lord Kelvin, who died on December 17, 1907.

Dr. Eric Gerard, the director of the Montefiore Electrotechnical Institute at Liège, Belgium, and professor in the University of Liège, died in Paris, on March 27, at the age of sixty years.

The American Society of Naturalists has decided to hold its annual meeting of Convocation Week, 1916, in New York City.

The next stated meeting of the American Ornithologists' Union will be held at the Academy of Natural Sciences, at Philadelphia, from November 14 to 16.

At the invitation of the technical committee of the Affiliated Engineering Societies of Atlanta, Ga., the Bureau of Standards will hold a conference in that city on May 2, 3 and 4, for the purpose of discussing the work of the bureau in connection with the national electrical safety code and the prevention of electrolysis of gas and water pipes, cable sheaths and other metallic underground structures.

The Puget Sound Marine Station will open its session at Friday Harbor, Wash., on June 26, 1916, and continue for six weeks. The teaching staff will consist of the following: Dr. T. C. Frye, University of Washington; Dr. H. S. Brode, Whitman College; Dr. Nathan Fasten, University of Washington; Dr. H. J. Van Cleave, University of Illinois; Mr. W. L. C. Muenscher, Sioux Falls, South Dakota; Mr. A. C. Jensen, Mt. Pleasant, Utah; Miss Edna M. Perry, Bellingham, Washington; Miss Annie May Hurd, Seattle, Washington; Mr. G. C. Woods, Walla Walla, Washington. The total expense for the six weeks is about $50. Those east of the Missouri River may add to the pleasure of the trip by joining Professor H. J. Van Cleave's party from the University of Illinois.

The United States Biological Laboratory, Fairport, Iowa, will be open to temporary investigators on June 15. While the laboratory is open the entire year, the mess and other special accommodations for summer workers will not be available until this date. The equipment and facilities of the station provide excellent opportunities for biological investigations of a general and specific nature, with particular reference to freshwater forms, and also for chemical and physical studies

relating to biological problems. Opportunities are especially good for studies relating to fish and mussels. Investigators desiring to occupy tables for the whole or part of the season should communicate with the commissioner of fisheries, Washington, D. C., or the director of the station.

THE *Experimental Station Record* states that four new Canadian entomological laboratories were completed during the summer of 1915, located respectively at Annapolis Royal, Nova Scotia; Frederickton, New Brunswick; Treesbank, Manitoba; and Lethbridge, Alberta. The laboratory at Frederickton is the most elaborate of these structures and is a two-story and basement brick building 24 by 30 feet, located on the campus of the University of New Brunswick. Its work has been especially directed toward the natural control of insects, notably the brown-tail moth, tent caterpillar, spruce budworm and fall webworm. The laboratory at Annapolis Royal is a wooden one-story and basement building, 26 feet square. It is located on the county school grounds and is equipped with special reference to combating the brown-tail moth and for studies of the bud moth, fruit worm and other fruit pests. It replaces a former temporary laboratory at Bridgetown, which is to be used as a substation wherever most needed. The laboratories at Treesbank and Lethbridge are of the bungalow type, the former being 12 by 16, and the latter, located on the Dominion substation farm, 23 by 20 feet.

AT the University of Chicago a contract has been made with the United States Department of Agriculture for the establishment in Julius Rosenwald Hall of a meteorological observatory of the United States Weather Bureau. Instruments for observation are to be placed upon the roof of the tower, and instruments for registering seismic disturbances and for other purposes of the bureau are to be installed in the building. Rain gauges and a thermometer shelter are to be placed on the campus. By the terms of the contract the faculty and students of the university may have free access, within reasonable limits, to the records of observations made and of data gathered; and printed matter containing the results of investigations based upon observations made in this observatory will show the cooperation of the university with the department.

WE learn from the *Auk* that Mr. W. Leon Dawson, of Santa Barbara, Cal., has made over his valuable collection of birds' eggs and nests to a board of trustees who are incorporating an institution to be known as the Museum of Comparative Oology, in which it is hoped to accumulate a representative collection of the nests and eggs of the birds of the world. Mr. Dawson is to have responsible control of the collection during his life in order to insure its proper care during the early years of the enterprise. At the expiration of three years, during which he will be engaged in field work in connection with the forthcoming "Birds of California," a campaign will be inaugurated for an endowment and a group of buildings suitable for housing the collection. A number of prominent oologists and ornithologists have been invited to form a board of visitors to cooperate with the museum management.

THE trustees of the National Dental Association have purchased a large private residence in Cleveland, O., as temporary quarters for a new Research Institute until adequate buildings can be erected. The Research Institute is supported entirely by the association, and the plan of organization is a corporation with a membership of sixty, twenty-seven of whom are elected by the trustees of the National Dental Association and known as commission members, and thirty-three are permanent members and are selected by the corporation. The board of nine trustees has chief responsibility for the conducting of the work in the institution and carried on under grants. They are assisted by an advisory board of eighteen. It is said to be the first institution of its kind in the world. Various problems contemplated for study are: Pyorrhea, dental caries, mouth infections, relation of baby foods to tooth structure, relation of glands of internal secretion to defective tooth structure, staining of teeth, etc. Part of the work will

be the collecting and distribution of information for educational work, particularly for the medical and dental professions. The present officers are: Dr. W. A. Price, Cleveland, president and managing director; Dr. Thos. P. Hinman, Atlanta, vice-president; Dr. Clarence J. Grives, Baltimore, secretary; Lefa A. Beman, Cleveland, assistant secretary; Edward A. Petrequin, Cleveland, treasurer. The trustees are: Dr. Weston A. Price, Cleveland, Harry J. Crawford, Cleveland, Dr. John V. Petrequin, Esq., Cleveland, Dr. Geo. W. Crile, Cleveland, Dr. Clarence J. Grives, Baltimore, Dr. Eugene R. Warner, Denver, Dr. Thos. P. Hinman, Atlanta, Edward A. Couzett, Dubuque, Iowa, and Dr. Homer C. Brown, Columbus, O.

The Anglers Association of Onondaga, of Syracuse, N. Y., one of the largest associations of the kind in New York State, and the New York State College of Forestry at Syracuse, have decided upon a cooperative plan for the utilization of the fine springs at the college nursery as a trout nursery and for fish ponds. The college furnishes the site and the anglers pay for the man to care for the fish, etc. The general plan is to care for the young trout fingerlings, received from the Conservation Commission in the spring, and to carry them over the summer in this nursery and then plant them in the fall, at a more favorable season and in better condition. This is the practise now so successfully followed at Rome, N. Y., under the leadership of Mr. Harry Ackley, president of the Rome Fish and Game Association. The fish nursery and ponds will be available to the college for the instruction of its students in the course on fish and game taught to forestry students by Dr. C. C. Adams.

UNIVERSITY AND EDUCATIONAL NEWS

The University of California has received the following gifts and subscriptions toward the equipment of the new 216-bed University Hospital (now being built in San Francisco from gifts of over $600,000): Mrs. James Moffitt, $5,000; an alumnus, $5,000; Mr. Alexander F. Morrison, $5,000; Mr. William H. Crocker, $2,616.50; Mr. Wallace M. Alexander, $2,000; a friend of the university, $2,000; Mr. N. Ohlandt, $1,500; Mr. Charles W. Merrill, $1,000; Mr. D. C. Jackling, $1,000; and the children of the late F. W. Dohrmann, $500.

The bill of the ways and means committee in the House of Representatives of the Maryland Legislature makes the appropriation of the state to Johns Hopkins University $50,000, a decrease of $25,000 from the grant of last year.

Professor Wilbur L. Cross, graduate of the English department of the Sheffield Scientific School, has been elected by the faculty of Yale University to be dean of the graduate school. He succeeds Professor Hans Oertel, who is now in Germany.

Ivey F. Lewis, Ph.D. (Johns Hopkins, '08), fromerly professor of botany in the University of Missouri, has gone to the University of Virginia as professor and head of the Miller School of Biology.

Mr. A. W. Dupler, of the University of Chicago, has been elected professor of botany at Lawrence College, Appleton, Wisconsin. Dr. R. C. Mullinix, who has been head of the department of biology, will continue as professor of zoology.

Mr. George F. Moznette has been appointed as assistant professor in entomology at the Oregon Agricultural College and Station to begin his duties on March 1.

Professor Ettore Marchiafava, a senator of the kingdom of Italy, known for his work on malaria and in other directions, has been appointed to the chair of clinical medicine at Rome left vacant by the death of Professor Guido Baccelli.

DISCUSSION AND CORRESPONDENCE

HORIZON OF THE SHARK RIVER (N. J.) EOCENE DEPOSITS

Some twenty-five years ago, while working over the Eocene molluscan material in the

Smithsonian Institution from the so-called Pamunkey of Maryland and Virginia, it became perfectly evident to the writer that the majority of the species were very similar to, or identical with, the more common species from the lower "Lignitic" or Bell's Landing horizon of Alabama.[1] Shortly afterwards he observed other specimens while on a trip in southern Virginia representing a higher "*Sellæformis*" horizon. All these faunas have since been ably worked up by members of the Maryland Geological Survey.[2]

Away to the northeast, but seemingly quite in the general line of outcrop of the Maryland Eocene, are the Shark River beds with a poorly preserved yet interesting fauna. Opinions of Conrad, Cook, Heilprin and Clark have varied as to whether these beds should be referred to the horizon of the near-by Marylandian deposits or should be relegated to a still older Eocene stage. The writer, however, has been quoted on several occasions[3] as believing that the Shark River beds should be placed above the general horizon of the Pamunkey Eocene, within a Mid- or Upper Eocene stage.

Since the data upon which this belief is founded have not been made known, it seems quite proper to place them on record that their validity may be intelligently discussed.

It may accordingly be noted:

1. That the absence of such characteristic Pamunkey species as *Ostrea compressirostra, Cucullæa gigantea, Dosiniopsis lenticularis, Crassatella alæformis* and huge *Turritellæ* and *Venericardiæ* seems to preclude the synchronizing of the Pamunkey and Shark River deposits.

2. That the Shark River beds are not *below* the Pamunkey beds from: (*a*) The fact that if they were they would naturally be the equivalent of some basal or Midway Eocene horizon. Certainly if such were the case there should be some trace in the Shark River beds of that great virile Midway fauna that stretches from the Carolinas to the Rio Grande, on the north, and from Trinidad to east of Brazil, on the south; the similarity should be as great between Shark River beds and Alabama Midway as between Pamunkey and Bell's Landing beds —in fact the "Lignitic" beds are more local in character than the more truly marine Midway. But the Pamunkey shows derivatives of the Midwayan in its *Hercoglossa, Cucullææ* and great *Turritellæ,* while these striking forms are absent from the Shark River deposits. (*b*) The fact that, as indicated above, if these beds are pre-Pamunkey they must also be pre-Midway, *i. e.,* older than the oldest known marine Eocene on this continent, which seems quite out of the question.

3. That the Shark River beds are Mid-Upper Eocene and above perhaps all of the Pamunkey horizons from: (*a*) The fact that the general aspect of the molluscan fauna is upper and not lower Eocene. Witness the presence of *Aturia* and not *Hercoglossa;* the large rotund *Caricellæ* closely allied to, if not identical with, the Claibornian forms showing nothing in common with the small slender Midway species; the *Fusoficula* of *penita* proportions and appearance and not of the older *juvenis* type; *Turritellæ* of non-carinate, Claibornian aspect; *Pleurotomariæ* of huge dimensions as in the Upper Eocene beds of the Carolinas though unknown in lower horizons; *Ostreæ* of the Claibornian *divaricata* (*i. e., sellæformis*) type and with nothing in common with *crenulimarginata* of the Midway or *compressirostra* of the Lignitic; *Pectens* of the types found in the Claiborne and Pope's Creek beds, with no resemblance to those of earlier horizons; *Crassatellæ* of the high, huge *alta* type of the Claibornian, with nothing in common with the lower Eocene forms; *Volutilithes,* similar or identical with Claibornian forms and without the *Athleta* characteristic of the Lignitic. (*b*) The fact that the coral from the Shark River beds noted by Vaughan is of a genus unknown from any other state "from a horizon below the Claibornian."[4] (*c*) The fact that although the vertebrate evidence on this question is very slight, "*Anchip-*

[1] *A. J. S.,* Vol. 47, p. 301.

[2] See especially Rept. '01, Eocene.

[3] Mon. 39, U. S. G. S., p. 17.

[4] *Op. cit.,* p. 17.

podus riparius is currently identified with *Trogosus* or *Tillotherium* of the Bridger Middle Eocene. If this identification is correct and if it came from the Shark River beds, then these are probably Middle Eocene, possibly later, but not earlier."[5] (*d*) The fact that the Pamunkey embayment or segment filled in seaward during Eocene time till the Carolina end of the arc was reached in late Eocene times, would suggest a similar age for the New Jersey beds at the other end of the arc.

The conclusions from the above outline of facts may be thus briefly summarized:

(*a*) The Eocene beds in New Jersey may be in the same trend of the Maryland Eocene outcrops, but this fact has little to do with the relative age of the deposits.

(*b*) The known Shark River fauna shows very little relationship with the comparatively near-lying Pamunkey faunas; still less with any known lower or basal Eocene, Midway fauna.

(*c*) The general aspect of the Shark River fauna with its many species closely allied to or identical with Claibornian forms would seem quite sufficient in itself to cause these New Jersey beds to be referred to a horizon *above* instead of *below* the mass of Pamunkey deposits.

(*d*) Data from other paleontologic sources are of a questionable nature, but so far as they go they seem to support the writer's contention.

Gilbert D. Harris

Paleontological Laboratory,
Cornell University,
Ithaca, N. Y.

[5] Matthew, *ex lit.*

A PHYTOPHTHORA ON OATS

While in the recently started experiment garden at Stanford University on February 10, I noticed on the leaves of volunteer oats markings such as I had not seen before.

On examining the material in the laboratory, the markings were found to be due to a species of *Phytophthora*. The markings may appear as spots or as stripes along one or both margins of the leaf, or as a stripe down the center. The diseased areas become yellowish, and then whitish when conidia are abundant. Later these areas, which sometimes have a water-soaked appearance, become brown or reddish-brown, and the parts shrivel and dry up.

The short, hyaline, unbranched conidiophores (4–5 × 15–300 μ) issue from the stomata on both sides of the leaves and usually bear a single ovate or obpyriform conidium. The conidia are quite large (30–42 × 42–78 μ, occasionally one is much smaller) and fall away with a small part of the conidiophore attached. They germinate by producing numerous zoospores. Chlamydospores were found crowded together in the tissues of some of the older diseased areas. They were globular, hyaline or very light yellow, some thin-walled and others thick-walled, and 12–18 μ in diameter. In some leaves oospores were also found abundantly. The oogonia were thin-walled and 30–39 μ in diameter. The globular oospores were 27–30 μ in diameter, the epispore being smooth, hyaline or light yellow, and about 2 μ thick.

The species is certainly very similar to *Phytophthora Colocasiæ* Rac. on the taro (*Colocasia esculenta*) in Java, India and Formosa, but a more extended study is necessary to determine its specific rank. It has been found in several fields about Stanford University and by the state highway near Mayfield, California. As a large percentage of the plants were infected in some localities, the fungus may become of considerable economic importance.

James McMurphy

Stanford University,
February 17, 1916

ENDURANCE OF THE PORPOISE IN CAPTIVITY

The New York Aquarium lost last year a most attractive exhibit, the bottle-nosed porpoise (*Tursiops truncatus*) which has lived in the large central pool of the building for more than twenty-one months.

The cause of its death was a mixed infection, which in a few days attacked every part of its skin, covering the smooth glistening surface with unsightly pustules. This infection

was clearly the result of keeping the animal in water pumped from New York Harbor, the only supply available for the large floor pools, under present conditions.

The water of the harbor is always of low salinity and is charged with sewage, its foulness being especially noticeable in midsummer.

The propoise had grown perceptibly since its arrival on November 15, 1913. Its weight at death was 293 pounds and its length eight feet. Four other porpoises received at the same time lived seven months in captivity, when they died of pneumonia in rapid succession.

Like the one referred to above their skins at death were also filth-infected, although not to the same extent. Our experience has shown that the porpoise readily endures captivity and might live much longer if pure sea water were available. Other porpoises will be obtained and equipment is now being installed for filtering the harbor water—an improvement that has long been needed at the Aquarium.

The school of porpoises contained both sexes and they were often observed mating. The loss of the females was especially disappointing as the prospects for breeding in captivity were promising.

All of these porpoises were constantly active and playful to within a few days of their deaths.

C. H. TOWNSEND
THE NEW YORK AQUARIUM

SCIENTIFIC BOOKS

A Treatise on Light. By R. A. HOUSTOUN, Lecturer on Physical Optics, University of Glasgow. Longmans, Green and Co., 1915. Pp. 478. $2.25 net.

To the student of optics familiar with the treatises of Drude, Preston, Shuster and Wood, and numerous other text and reference books on optics, there would appear to be little need for a new text in this field. Professor Houstoun's treatise is, however, unique in scope and treatment, and will doubtless prove of great value both as a text and for reference.

In scope, this treatise covers both theoretical and physical optics, together with geometrical optics, vision, photometry, illumination, spectroscopy and X-rays. Part I. deals with Geometrical Optics, Part II. with Physical Optics, Part III. with Spectroscopy and Photometry and Part IV. with Mathematical Theory. An extremely concise treatment of each subject makes it possible to cover this wide field in so few pages, the style is lucid and free from unnecessary explanation and deductions. Except, perhaps, in the chapter on the nature of light, the treatment is nowhere exhaustive or profound, and is well adapted to the use of advanced undergraduate students.

Part I., on Geometrical Optics, deals in seven chapters with the elementary theory of image formation, the theory of the simple optical instruments and the determination of refractive indices. The third order defects of images (Seidel aberrations) are barely mentioned. This section of the book, while an excellent teaching text in that it presents a well-balanced outline of the subject, would be much more valuable if it included a little modern technical optics dealing with lens calculation, the third-order aberrations and precise methods of testing.

The hundred pages on Physical Optics is a discussion of the velocity, interference, diffraction and polarization of light in six chapters. A rather full treatment of the diffraction grating is given, but otherwise the matter presented is quite academic and very concise. On page 190 statements (3) and (4) regarding interference between two beams of plane polarized light evidently require revision. The description of improved polarizers and analyzers does not mention those devised by Brace and used with such success by his students.

Part III., entitled Spectroscopy and Photometry, contains two chapters on the spectroscopy of the visible spectrum, a chapter on the ultra-violet and one on the infra-red and X-rays. The remaining three chapters are devoted to Photometry and Spectrophotometry, the Eye and Color Vision and Lamps and Illumination.

The two chapters on general spectroscopy, for their length, could hardly be improved upon in choice and presentation of material. The chapter on the ultra-violet impresses the re-

viewer as rather meager, many of the more important phenomena connected with ultra-violet light not being mentioned. The same criticism might be made of the chapter on the infra-red spectrum which includes a page on cathode rays and four pages on X-rays. The three chapters on photometry, illumination and the eye are the least satisfactory in the whole book. The treatment is academic, scanty and contains little that is valuable and modern, but it is a decided advance to include these subjects at all in a general text on light.

Part IV., on the mathematical theory of light, gives an excellent presentation of the electromagnetic theory in six chapters totaling one hundred pages. The opening chapter on the nature of light, giving the gist of a number of the author's papers on the subject, needs no apology on the ground that it is original material. The final chapter is on the relative motion of matter and ether.

Numerous problems are given at the end of each chapter. These and the general presentation and arrangement of matter make the treatise well adapted for class-room work for third year students in the average university. If supplemented by a little modern technical optics it would serve very well as an introduction to applied optics.

P. G. Nutting

Rochester, N. Y.

John Shaw Billings. A Memoir. By Fielding H. Garrison, M.D. New York and London, George P. Putnam's Sons, 1915. Pp. 432.

I was first brought into contact with Dr. Billings in the Satterlee Army Hospital, Philadelphia. He was the executive officer and not long after my being ordered there I was appointed assistant executive officer. This threw us much together. One evening in his quarters he became unusually free and confidential in his conversation and in an infrequently interrupted monologue he told me in detail the story of his early life and trials. These are sufficiently set forth in this admirable volume. That one could overcome such obstacles and finally reach the international fame which crowned his later life is an inspiring lesson to every young man and especially every young doctor.

The last time I saw him was not long before his death. He took the time to show me all over his latest triumph, the New York Public Library.

Before he was fifteen he bought a Latin grammar and dictionary in order to translate the classical quotations encountered in his always omnivorous reading. With a geometry, some Greek books, etc., he eked out his knowledge sufficiently to enter Miami University, graduating in arts in 1857 and in 1859 in medicine. His early struggles with poverty (during one winter he lived on 75 cents a week) were much lightened by his becoming demonstrator of anatomy in 1860.

In 1861 he began his wonderful career first as an army surgeon. His remarkable powers of work and of organization were at once called into play. This was the first phase in his professional life. From the field he was sent to the surgeon general's office. In this new sphere he soon became the first medical bibliographer not only of our time, but of all time. I remember seeing him more than once flanked right and left by two appalling piles of journals checking title after title for cataloging. The result was year after year the great Index Catalogue of the Surgeon General's Library and later the Index Medicus, the two greatest contributions ever made to medical bibliography.

These two services in the field and in the library, with much labor in the museum, would be enough for most men. But he added a third career in sanitation and hospital construction. In the course of his life he planned seven great buildings, the Johns Hopkins Hospital being the first and the New York Public Library the last. While as Dr. Hurd has pointed out the "housekeeping" part of that hospital was not perfect, yet we must remember that even Jupiter sometimes nods. In one of these somnolent spells Billings actually used candelabræ as a plural.

As a statistician and scientist he won a prominent place. His address in 1881 at the International Medical Congress and in 1886

at the British Medical Association were veritable triumphs.

His final seventeen years at the New York Public Library were the culmination of his laborious and distinguished life.

Samuel D. Gross, Weir Mitchell and Billings were by all odds the most widely known American medical men in the last half of the nineteenth century.

Dr. Garrison's book is delightful. He is judicious in his selection from Billings's Letter and Addresses. His style and his general review of the various stages of Billings's development and of his character and personality leave nothing to be desired. The only regret I have is that he takes as I think a backward step in using the archaic and souperfluous "u" in labour, endeavour and their similars.

W. W. KEEN

SPECIAL ARTICLES

EFFECT OF COLORED LIGHT ON THE MOSAIC DISEASE OF TOBACCO

IN connection with extended work on the mosaic disease of tobacco in this section of the Connecticut Valley, it was found that plants grown under shade or tents appeared to be much less affected with the mosaic disease than those grown in the open. This fact had previously been noted by Sturgis[1] in Connecticut, and the writer, in conjunction with other work on this disease, outlined experiments relative to a study of light conditions on the intensification or reduction of the disease.

While the writer's preliminary work was in progress, his attention was called to a paper by Lodewijks[2] published in 1910, which dealt with the effects of colored light on mosaic diseased plants. As a result of his experiments Lodewijks stated that a cure was effected by blue light; red light diminished the disease, and suffused light checked it somewhat. This is not the place for an extended discussion of his methods of experimentation, but in brief it may be stated that the diseased leaves of the plant were enclosed in a cloth hood of the desired color, the apparently healthy basal leaves remaining uncovered and exposed to normal daylight. After some time the hoods were removed and the plants examined for symptoms of the mosaic disease. The results obtained, if substantiated, would be of great interest and value. In order to satisfy himself the writer duplicated in so far as was possible the work of Lodewijks, employing the same methods and cloth hoods of approximately the same texture as those used by him in his experiments. The hoods were allowed to remain over the plants for thirty days; at the end of this period they were removed and the plants carefully examined for visible symptoms of the disease. The results obtained were in brief as follows:

The plants covered with the red cloth hoods showed a diminished color variation between the light and dark green areas of the diseased leaves, and all new growth showed a more or less pronounced mottling. After remaining a week exposed to normal daylight, all the new growth was badly diseased. Healthy plants inoculated with juice from the treated leaves became diseased in from ten days to two weeks. Control inoculation remained healthy. From the above results it may be stated that there is a diminution in color variation in diseased leaves, not of a permanent character, however, and the active principle of the disease remains very virile and highly infectious.

Similar experiments carried on with blue cloth hoods gave the following results: On three plants after thirty days' treatment no visible symptoms of the mosaic disease were observable, although there was a slight tendency towards curling noticeable on a few leaves of the new growth. One other plant, however, showed a slight mottling on two of the young leaves. Two weeks after the hoods were removed, the first three plants did not show any marked symptoms of the mosaic disease other than a faint mottling of a few

[1] Sturgis, W. C., "On the Effects on Tobacco of Shading and the Application of Lime," Conn. Agr. Exp. Sta. Ann. Rept. 23: 252–61, 1899.

[2] Lodewijks, J. A., Jr., Zur Mosaikkrankheit des Tabaks. Rec. Trav. Neerlandais, Vol. 7, 107–29, 1910.

leaves. The fourth plant developed mosaic again, but not as seriously as before treatment. Healthy plants inoculated with the juice of leaves from the first three plants contracted the disease almost without exception, as they did from the fourth plant, which showed the disease. Here we have a case of *apparent* recovery, but the plants still contained the active principle of the disease in a very infectious form. The percentage of infection from these plants is given below:

From plant No. 1, 8 healthy plants developed 6 cases of mosaic in 18 days, 75 per cent.

From plant No. 2, 8 healthy plants developed 8 cases of mosaic, or 100 per cent.

From plant No. 3, 10 healthy plants developed 9 cases, or 90 per cent.

From plant No. 4, which showed a slight trace of the mosaic, 100 per cent. infection was secured.

These results show that when blue light is used, there is a suppression of the leaf color variation more or less permanent in character, the treated plants with one exception showing no typical symptoms of the disease for at least two weeks subsequent to the removal of the hoods. It can not be said, however, that the disease was controlled, as inoculation of healthy plants with juice from diseased leaves produced the trouble in nearly every case. The active principle of the disease was still present in apparently normal, fully recovered leaves, and was highly infectious.

These experiments were repeated and the same results obtained in practically every case. They do not entirely harmonize with the results obtained by Lodewijks, but do in so far as the plants under the blue hoods showed an *apparent* recovery; but as Lodewijks, so far as the writer is aware, did not try any reinoculation experiments, he overlooked the fact that the active principle might still be contained in the leaves and that it might be capable of transmission. This is clearly shown in the above experiments, and there is no doubt that the active principle of the disease is still present in plants treated in this manner. It is evident that the treatment of plants as above recorded does not destroy the active principle, whatever may be its character, the treated leaves apparently still containing it, very probably in the same manner as do parts of the plant which do not show visible symptoms of the disease normally, such as the stem, lower leaves and roots—the juices of which are often highly infectious.

More detailed results of these experiments are to be published later in connection with a report of work on the mosaic disease of tobacco as carried on at this station.

George H. Chapman
Massachusetts Agricultural
Experiment Station

THE NATIONAL ACADEMY OF SCIENCES

At the annual meeting of the Academy to be held on April 17, 18 and 19, the program of the scientific sessions will be as follows:

Auditorium, National Museum. Public scientific session for the reading of papers.

On Permeability of Endothelia: S. J. Meltzer.

The Influence of Morphin upon the Elimination of Intravenously Injected Dextrose: I. S. Kleiner and S. J. Meltzer.

The Sex of a Parthenogenetic Frog: Jacques Loeb.

It seemed of interest to determine the sex of frogs produced by artificial parthenogenesis. The first experiments in this direction by Loeb and Bancroft had been made on a frog and a tadpole of about four months old. The gonads of both sexes contain eggs at that age and it was only with approximate certainty that the sex of our parthenogenetic specimens could be determined. As far as we were able to judge the sex in the two cases referred to was male. The writer has since succeeded in keeping a number of parthenogenetic frogs alive for about one year and one of them was recently killed and the gonads sectioned and examined. They were found to be testicles containing well-developed spermatozoa. This confirms the former statement of Loeb and Bancroft that the frogs produced by artificial parthenogenesis are males.

Finer Mechanisms of Protection from Infection: Simon Flexner.

The biological phenomena associated with recovery from bacterial infections among animals remained largely unexplained until the era which

ushered in the antitoxic treatment of certain bacterial diseases and notably diphtheria and tetanus. Since then, data have accumulated rapidly. No difficulty is encountered in explaining antitoxic immunity, so called, which is a process essentially of neutralization—of a toxic body with the antitoxic antagonist. But no such simple explanation suffices to account for the process through which living bacteria and not their waste products alone are destroyed. Several independent reactions are distinguishable: the assembling (agglutination) of the bacteria, their englobing by cells (phagocytosis), and their disintegration inside and outside of cells (bacteriolysis). The processes are partly inherent in the animal host, partly subject to augmentation. The experiments to be described deal with the finer mechanism of the disposal of bacteria through phagocytic activity and the action upon the mechanism of antiseptic chemicals which have been or conceivably may be recommended for the treatment of the bacterial infections because of the possession of bactericidal properties.

The Distribution of the Chondriosomes to the Spermatozoa in Scorpions: EDMUND B. WILSON.

The spermatozoon carries into the egg two kinds of bodies that have been supposed to play a definite part in heredity; these are the chromosomes and the chondriosomes, the former belonging to the nucleus, the latter to the protoplasm or cytoplasm. The chromosomes (with certain specific exceptions) undergo in general an accurately equal distribution to the germ-cells; whether this is also true of the chondriosomes is not certainly known, though an approximately equal distribution undoubtedly occurs in some cases. In the Arizona scorpion, alone among animals thus far examined, an accurate quantitative distribution of the chondriosome-material may be demonstrated owing to the fact that prior to the spermatocyte-divisions all this material becomes concentrated in a single, definite body in the form of a ring. This body, a new type of chondriosome, divides somewhat after the fashion of a heterotype chromosome-ring, each spermatid receiving exactly one fourth of its substance. In the California scorpion the phenomena offer a remarkable contrast to this, agreeing in the main with the European form *Euscorpius carpathicus* as described by Sokolow. The ring is here absent, its place being taken by about 24 separate, hollow spheroidal bodies that show no evidence of division at any time and establish no definite relation to the spindle, but are passively segregated by the spermatocyte-divisions into four approximately equal groups. Each spermatid thus receives as a rule six, not uncommonly five, rarely seven of these bodies, which give rise to the nebenkern like the products of the ring in the Arizona form. In both cases the chondriosome-material has the same origin, seems to play the same part in the formation of the spermatozoon (nebenkern, envelope of the flagellum) and shows the same staining reactions (Benda method). Interesting questions are thus raised concerning the principle of genetic continuity as applied to the chondriosomes or to other specific cell-components.

Further Studies of the Protein Poison: VICTOR C. VAUGHAN.

In 1903 Wheeler and I discovered a poisonous group in the protein molecule. This work has been extended by my students and myself and confirmed by others. Since my latest publication on this subject, the following new facts have been discovered in my laboratory: (1) *Skin Reaction.*—When a drop of an aqueous solution of the poison is placed on the normal skin and the epidermis covered by the drop abraded, there results a local inflammatory process. Within a few minutes the skin about the point becomes edematous, resembling a hive, and later develops a redness which gradually fades. This reaction is similar to the specific reactions which may be developed in certain diseases and develops in the skin of normal individuals because the poison has already been set free in vitro. (2) *Absorption from the Alimentary Canal.*—I have stated that the protein poison is harmless when taken by the mouth for two reasons: (1) it is broken into harmless groups by the digestive ferments and (2) it diffuses through the intestinal walls too slowly to have any deleterious effect. We have found that when given in relatively large amounts, especially on an empty stomach, the protein poison may be absorbed in sufficient quantity to cause death from either acute or chronic intoxication. In the latter, a typical and marked fatty degeneration of the liver and kidneys results. Moreover, we have demonstrated that in both acute and chronic intoxication the poison may be detected in the liver, kidneys, lungs, brain and other tissues. It can be extracted and its action demonstrated by intravenous injection in guinea-pigs. (3) *Combination with Proteins.*—The protein poison combines with certain proteins and in these combinations the acidity of the poison and its toxicity are modified.

SYMPOSIUM ON THE EXPLORATION OF THE PACIFIC

Arranged by W. M. Davis

(By invitation of the Program Committee)

On Exploration of the Pacific: W. M. Davis.

The unsolved problems of the Pacific can not be settled by a continuation of independent and short-lived explorations, such as have heretofore been undertaken. Future work should be broadly areal, rather than local as on single islands, or linear as in single voyages. It should be continuous through ten or twenty years, so that its scientific directors may repeatedly inspect the uncertain elements of their work, and thus gain in the earlier years the expertness necessary for the critical study of the most difficult problems through the later years of their explorations. The type of investigation needed in various branches of science is furnished by the repeated traverses of the Pacific on many interwoven routes in the course of the magnetic survey of the earth by the Carnegie Institution of Washington. Problems of a century or more ago were bravely attacked in adventurous voyages of discovery. Problems of a generation ago were earnestly approached by less adventurous and more scientific voyages of investigation. But the demands of modern science have become exacting. So delicate are the variations of temperature and density in ocean water at various depths, so elaborate are the phenomena of oceanic and atmospheric circulation, so complicated are the details of shoreline features by which changes in the level of the land or reversed changes in the level of the ocean are to be inferred, so involved are the biological problems of pelagic islands, that the detached facts of earlier scientific voyages must now be supplemented by more continuous bodies of facts. The development of a comprehensive plan for the exploration of the Pacific is worthy of the National Academy of Sciences, and it is to be hoped that the commendation of such a plan by the Academy may lead in the next five or ten years to its realization.

The Importance of Gravity Observations at Sea in the Pacific: J. F. Hayford.

A New Method of Determining Gravity at Sea: L. J. Briggs.

The method employed in measuring g at sea consisted in observing the height of a mercurial column in vacuo necessary to maintain a confined mass of gas at a constant volume when kept at a constant temperature. The mercurial column is contained in a capillary glass tube bent into a zigzag or spiral above the gas chamber, and expanding at the top of the capillary into an evacuated observing bulb which contains a fixed iron point. The capillary tube is sealed through the upper end of the gas chamber, the lower end of the capillary tube dipping beneath mercury in the bottom of the chamber. The pressure of the nitrogen in the gas chamber (about 72 cm.) is so adjusted that at the temperature of melting ice the mercury surface at the top of the column is in contact with the fixed point at the center of the evacuated bulb. The gas chamber is then sealed. The zigzag in the glass capillary makes it possible to raise or lower the observing bulb slightly with reference to the gas chamber, the motion being controlled by a micrometer screw mounted on the gas chamber. In making an observation, the apparatus is adjusted to a vertical position in a bath of melting ice, and the observing bulb is raised or lowered until the mercury is in grazing contact with the fixed point. Under these conditions the quantity of mercury in the observing bulb is always the same, so that the quantity of mercury in the gas chamber is also constant. The gas volume is therefore constant and the measurements are made at constant pressure. The relative value of g at two stations is therefore inversely proportional to the height of the mercurial column at these stations. The height is represented by the micrometer reading plus a constant term determined from a manometer connected with the gas chamber at the time of sealing. On shipboard the ice tank is hung in gimbals which are suspended from spiral springs. The apparatus has been used in measurements from Sydney to San Francisco, and from New York to San Francisco, via Panama. The mean probable error of observations at base stations during the latter voyage, in which three instruments were used, was 1 part in 60,000. Apparent anomalies were observed at sea on both sides of the Isthmus of Panama, along the coast of Lower California and off the California coast near San Francisco.

The Problem of Continental Fracturing and Diastrophism in Oceanica: C. Schuchert.

A presentation of the problems connected with Oceanica, the most mobile region of the Pacific Ocean, and with the fracturing and foundering of Australasia within the area.

Petrological Problems in the Pacific: J. P. Iddings.

A number of geological problems of the first magnitude are also petrological ones since they involve the material of the lithosphere, which is only known through a study of the rocks.

Throughout the vast extent of the Pacific Ocean scattered volcanic islands furnish us with material evidence of the composition of the suboceanic portions of the lithosphere. A thorough investigation of the rocks of these islands will contribute to our knowledge of the distribution of various igneous rocks, that is, to the problem of petrographical provinces which involves the question of lateral heterogeneity of the earth.

Closely allied to this is the problem of isostacy, or the relation between the major features of the relief on the earth's surface and the density of the underlying lithosphere. Igneous rocks from continental regions should average lighter than those from deep oceanic regions. Preliminary estimates appear to confirm this expectation, but much more data regarding the rocks of deep sea islands are needed to establish the relationship.

An exhaustive study of the rocks of the Pacific islands will determine the character of each group as either the summits of volcanoes built up from the sea bottom or partly submerged remnants of a former continental area.

Afternoon Session

2.30–6.00 P.M.—Auditorium, National Museum.

A New Form of Metamorphism: ARTHUR KEITH (introduced by GEORGE F. BECKER).

Many Appalachian rocks are known which appear to be massive plutonics and have been called quartz diorite. Some evidence against this was known from the first, but their metamorphic nature is now considered settled. These rocks form bodies with shapes usually somewhat elliptical, but also lenticular, in sheets or dike-like masses. Their larger relations are: (1) gradation into the enclosing rocks; (2) occurrence only in graywacke or similar rocks; (3) thickness, rarely over three feet; (4) lack of igneous rock in the same region; (5) presence at many horizons; (6) occurrence over thousands of square miles. The principal minerals are quartz, hornblende or biotite, garnet, albite and oligoclase, the most conspicuous being hornblende, biotite and garnet. These obliterate the older minerals, and their prisms are disposed at random in marked contrast with the older parallel structures. The most striking assemblage is a spheroid composed of concentric shells of different mineral contents. These rocks were metamorphosed from graywacke or similar rock under heat and pressure but no movement. They raise anew the old question of the formation of igneous rocks from sediments. It appears, however, that they were not fused as a mass, but that their individual minerals grew through the agency of solutions. The process is of wide extent and is available as an accessory in forming plutonic rocks.

Contributions to the Petrology of Japan, Philippine Islands and the Dutch Indies: J. P. IDDINGS and E. W. MORLEY.

Volcanic rocks have been collected from thirteen active volcanoes and from other localities in Japan, and chemical analyses have been made of sixteen of them. The igneous rocks of Luzon, P. I., were collected and studied, and six analyses made. They bear strong resemblances to rocks of Japan. In the Dutch Indies the leucitic rocks of Java, Bawéan and Celebes were collected, together with the associated lavas and intrusive rocks. Of these twenty-nine have been analyzed, besides seven from Timor and Sumatra. The leucitic rocks of Celebes were found to be much more extensive than heretofore supposed.

SYMPOSIUM ON THE EXPLORATION OF THE PACIFIC

(*Continued from the Morning Session*)

The Extent of Knowledge of the Oceanography of the Pacific: G. W. LITTLEHALES.

The accumulated oceanographical observations in the Pacific relate principally to the surface and the bottom. The intermediate depths have been little investigated. The materials from centuries of voyaging and from the expeditions for sounding the ocean sent forth since the last quarter of the nineteenth century, when deep-sea soundings first began to be taken in the Pacific, have provided information of the distribution of barometric pressure and winds over this vast tract and also of the general aspects of surface circulation, temperature and salinity. The manuscript sheets of the United States Bathymetrical Chart, containing all the authentic deep-sea soundings, are offered in evidence to show the extent to which the basin has been sounded and the distribution of bottom deposits made known, and to prove the inadequacy of existing measurements to define the contours of configuration beyond the continental shoulder. In the North Pacific there is a tract twice as large as the United States which has been crossed by only a single line of soundings at intervals about 250 miles wide apart; and a number of instances exist in which tracts as large as the United States remain entirely unfathomed. The deposits on the floor of the ocean have generally been penetrated only to the depth of a few inches, and little is known of their thickness or stratification. Of the variations, from

season to season and from year to year, of the temperature, salinity and gas-content in the depths of the Pacific, no observations have been made—not even in the lesser depths throughout which extends the interchange of heat between the ocean and the atmosphere; and consequently there is no knowledge of the import of such changes upon the variations of climate and of physical and biological oceanography. The observational foundation for investigating the ocean from the standpoint of thermodynamics does not exist.

Marine Meteorology and the General Circulation of the Atmosphere: C. F. Marvin.

The proposal to organize a marine exploration of the Pacific ocean for making carefully planned scientific observations in oceanography, gravity, atmospherics and related subjects claims the great interest of the Weather Bureau and affords an opportunity to utilize the meteorological data now in the archives of that institution and hereafter to be collected by it in the discussion of observations to be collected during the expedition. Reports are now received by the Weather Bureau from 175 vessels traversing the main routes mostly of the Pacific oceans. Weather maps of the oceans can be constructed on some occasions at least, and in any case it may fairly be said that the proposed exploration must of necessity contemplate supplementing the meteorological data it collects by the more or less simultaneous information of related nature collected from every other vessel then at other points over the adjacent oceans. The greatest need in atmospherics of the present time is free air data. To secure these in fullest measure will require, at times at least, two points of observation one or two miles apart, for the purpose of triangulation as it were, and the expedition should be planned to provide for such a possibility as well as that of following free balloons by the aid of a small high-speed launch or sister ship of appropriate character. The meteorological observations that might form the working program of the expedition will be indicated and the personnel suggested. The paper will refer to or briefly summarize the data obtained from aerological work in the United States and draw inferences therefrom as bearing upon accepted theories of the general circulation of the atmosphere.

On the Distribution of Pacific Invertebrates: Wm. H. Dall.

Mr. Dall will point out the importance of the distribution of marine invertebrates, as one of the keys to the former distribution of land masses, and to our very imperfect knowledge of their distribution in the Pacific. Certain species, usually those inhabiting the reefs and comparatively shallow water, are very widely distributed over the region usually referred to as Indo-Pacific; but when a careful collection of the species belonging to any isolated island or group is available it becomes evident that a large proportion of them are local and combine to form a local fauna. A knowledge of these faunas is necessary before any satisfactory discussion can be had of the presumably Tertiary fossiliferous deposits which are found fringing the more elevated Pacific islands. The land shells of the Hawaiian and Tahitian groups indicate a high antiquity for their isolation according to Pilsbry, the most eminent student of these animals. The facies of the Tertiary fossils obtained by Ochsner on the Galapagos Islands indicates a derivation from the American rather than the Indo-Pacific fauna, with which the recent invertebrates are commingled. These facts indicate the interest which attaches to a wider knowledge of the Pacific faunas.

Land Mollusca of the Pacific: H. A. Pilsbry.

Present knowledge of Pacific land snail faunas is fairly adequate only for the Hawaiian and Society groups, but fragmentary data are available for many other islands. Some distinctively continental families extend as far out as Fiji, the western Carolines and the Bonin Islands. Beyond this there is another fauna, its striking feature being the absence of all highly evolved continental groups. This Pacific fauna consists partly of groups known by paleontological evidence to be old (such as the Succineidæ and Endodonts), and partly of a series of families having a primitive organization resembling aquatic air-breathing snails; *Achatinella* and *Partula* being the best known representatives. These hold a relation to the higher land snails analogous to that of the monotremes to placental mammals. Their adaptive modifications often parallel those of fundamentally diverse continental snails. The hypothesis that Pacific snails reached the islands by oversea drift leaves the absence of higher snails unexplained. The distribution of the faunas and their antique aspect suggest that there were large antecedent land masses, upon which the present relatively modern volcanic islands were superposed during subsidence.

Marine Algæ of the Pacific Islands: W. G. Farlow.

In any future expedition to the Pacific Islands

the plankton species should, of course, be collected wherever and whenever possible. In our present fragmentary knowledge of the littoral and sublittoral flora of the Pacific, it is not possible to say just what are likely to be the most important general problems ultimately to be investigated. What is first needed is a more detailed knowledge of the flora of certain centers than we at present possess. A practical question is what regions can be better explored by a special expedition and what regions can be sufficiently well studied by resident algologists. In the latter category should be included the islands on the western limit as the Bonin and Loochoo Islands and Formosa, now studied by the Japanese and the outlying Sandwich Islands where large collections have recently been made by some of our own algologists. The flora of the Philippines, although not well known, can be studied from collections easily made by local botanists. From the islands in Polynesia proper, as the Fiji and Samoa Islands which lie on the route from Australia to North America we have a certain amount of material which has been studied by experts, as Harvey and Grunow, but of the islands to the east of the Friendly Islands we have, with the exception of Tahiti, almost no knowledge. It therefore seems to be advisable that an exploring expedition should make the Fiji Islands or Samoa a center from which to explore the islands to the eastward as far as the Marquesas Islands. If means permit, starting from the same base, it would then be desirable to visit the islands extending as far to the northwest as the Caroline and Ladrone Islands, of whose flora we have a partial knowledge from collections made by some of the exploring expeditions of the last century.

Problems of the Pacific Floras: D. H. CAMPBELL.

The Pacific as a Field for Anthropological Investigation: J. W. FEWKES.

There is no large island in the Pacific ocean which was uninhabited by man when discovered by Europeans, and several show evidences of human occupation for a considerable antiquity. Our knowledge of the Polynesians is very deficient. This race presents many anthropological problems of great interest. From what direction, how and when did man migrate across the Pacific from one isolated island to another; how many traits of ancestral culture still remain, and how much have they been modified by oceanic insular environment, are questions which await intensive work in this field before they can be satisfactorily answered. Where there are so many unsolved problems, it is almost impossible to single out one in preference to others; but perhaps that which appeals most directly to us is the part the Pacific may have played in the aboriginal peopling of America. We know next to nothing of the physical features, much less of the language and comparatively little of the material culture of this race. Our knowledge of the history of the inhabitants of the Pacific islands is small. There are archeological remains scattered from Java to Easter Island. Our knowledge of the physical anthropology, linguistics and ethnology of Australia is very limited. Much that has been published ought to be critically examined and amplified by intensive studies. Anthropological work in the Pacific will be a service to science by shedding a flood of light on culture history. The harvest is sure to be great if we can find the man competent to gather it.

PAPERS OF THE REGULAR PROGRAM

Hereditary Transmission of Defects resulting from Alcoholism. (By invitation of the Program Committee.) CHARLES R. STOCKARD.

Recent Observations on the Activity of some Glands of Internal Secretion: W. B. CANNON.

Studies on conditions of activity of the adrenal glands have shown that during emotional excitement they secrete into the blood a substance which affects the bodily organs in a manner simulating the nervous influences of strong emotions. Electrical studies of the thyroid gland indicate that it also is brought into action in great emotional excitement, both by nervous and by chemical stimuli. These glands have a routine function without which certain bodily processes are not normal. They may also be reasonably regarded as having emergency functions which are called forth in times of emotional stress and are important for the needs of the organism (*e. g.*, for struggle) under such circumstances.

Studies in the Water Content of the Nervous System: H. H. DONALDSON.

8:00 P.M.—Auditorium, National Museum.

First William Ellery Hale Lecture, by Henry Fairfield Osborn, president of the American Museum of Natural History. Subject: "The Origin and Evolution of Life on the Earth." (Illustrated.)

The lecture will be followed by a conversazione in the art gallery of the museum. All members of the scientific societies of Washington, with ladies,

are cordially invited to attend both lecture and conversazione. No cards are necessary.

TUESDAY, APRIL 18

Morning Session

10:30–12:45 A.M.—Auditorium, National Museum. Public scientific session for the reading of papers.

Some Recent Results of Solar Research: GEORGE E. HALE.

The new results include photographs and stereograms of the solar atmosphere made with a 13-foot spectroheliograph; part of a new map of the sun-spot spectrum, on a scale of one centimeter to the angstrom, showing the magnetic phenomena of sun-spots; illustrations of the Stark effect for hydrogen and lithium; and observations indicating that the northern and southern sun-spots of the present cycle, irrespective of latitude, are opposite in magnetic polarity to the corresponding spots of the preceding cycle, while the chromospheric vortices associated with spots did not undergo a similar reversal in sign at the minimum.

An Investigation of the Suggested Mutual Repulsion of Fraunhofer Lines: CHARLES E. ST. JOHN (introduced by G. E. HALE).

Those who assign an important rôle to anomalous dispersion in the solar atmosphere deduce from the theory a mutual influence between the components of close pairs of Fraunhofer lines, which operates to increase their distance apart. Investigations now nearing completion show that the relative positions of lines in close solar pairs conform to their relative positions in terrestrial spectra to the same degree of precision as free-standing solar lines which are not under the influence of neighboring lines, and the violet and red components are not displaced to the violet and red respectively as the theory demands that they should be in the solar spectrum.

Anomalous Dispersion Phenomena in Electric Furnace Spectra: ARTHUR S. KING (introduced by G. E. HALE).

Strong anomalous dispersion effects have been produced by passing white light through metallic vapors in an electric furnace. A study under high dispersion of spectrum lines very close together gave no indication of the mutual repulsion predicted by Julius when one of the lines in question shows high anomalous dispersion. Other experiments, in which the wave-length of a line was measured when alone and also when very close to a strong line of another element, gave no difference greater than 0.001 angstrom.

Illustrations of the New Spectroscopic Method of Measuring Stellar Distances: WALTER S. ADAMS (introduced by G. E. HALE).

The method of determining the actual light emission of a star from the appearance of the absorption lines in its spectrum has proved a valuable way of measuring stellar distance, since the difference between the actual and apparent brightness of a star depends only on its position in space. The new method has been used to determine the distance of a remarkable pair of faint stars in the southern sky, showing that the components move in parallel paths at the greatest known stellar velocity—about 600 km. a second. Another interesting application relates to the total light emission of the sun. By simply comparing the relative intensities of five lines in the solar spectrum the apparent brightness can be estimated with an accuracy comparable with that of direct photometric measurement.

Some Results with the New 10-inch Photographic Telescope: HARLOW SHAPLEY (introduced by G. E. HALE).

The new Cooke photographic triplet of 10 inches aperture, focal length 45 inches, has been used with a 15-degree objective prism to photograph spectra of faint stars. The scale is three minutes of arc to the millimeter and a single plate covers nearly 400 square degrees. As many as 10,000 spectra have been photographed at one exposure. The instrument has been applied to the study of Cepheid variables, and the spectra of about a dozen have been found to vary periodically with the light.

The Pyranometer, an Instrument for the Measurement of Sky Radiation: C. G. ABBOT AND L. B. ALDRICH.

The authors have perfected an instrument to measure the radiation originally forming a part of the beam of rays from the sun, but which reaches the observer by scattering from all parts of the sky. The instrument can also measure the radiation outward toward the sky and space at night, comprising those long wave-length radiations which are purposely excluded in the daylight measurements. For the first purpose the instrument is provided with an optically figured hemispherical shell of ultra-violet crown glass about 2 mm. thick. The diameter of the shell is about 25 mm. For nocturnal radiation measurements this shell is not employed. The horizontal measuring surface is a thin blackened strip of manganin about

6 mm. long, 3 mm. wide, and 3/1,000 mm. thick, placed centrally and level with the surface of a circular nickel-plated copper plate 12 mm. thick, 75 mm. in diameter. The manganin strip is electrically insulated from the copper plate by means of thin strips of mica which come exactly to the common surface of the plate and strip. Underneath the manganin strip are cemented two thermo-elements of tellurium and platinum joined in series, and whose cool junctions are embedded in opposite halves of the copper plate. A polished nickeled hemispherical shutter encloses the outside of the glass hemisphere, and when it is open the radiation from the sky passes through the hemisphere, falls upon and is absorbed by the upper surface of the manganin strip. Thus the thermo-elements are warmed and deflection of the galvanometer connected with the apparatus would ensue. But this is reduced to zero by means of an auxiliary current supplied by a potentiometer arrangement. Having secured the balance by means of the potentiometer circuit, the shutter is now closed and a heating current is applied to the manganin strip until the temperature is again raised so that with the same potentiometer current the galvanometer again stands at zero. In these circumstances, as in the Ångström pyrheliometer, the energy of the current expended in heating the strip is equal approximately to the energy of the sky radiation which heated the strip before. This apparatus has been used with excellent results on the snow, the sky, the sky and the sun, and the sun alone. In the latter case the instrument was compared with a standardized silver-disk pyrheliometer. Corrections having been made for the inclination of the rays to the surface of the horizontal sky radiation instrument, reflection of glass, and imperfect absorption of the lamp-black close agreement was found between the results derived from the two kinds of apparatus. We are of the opinion that with this apparatus the sky radiation can be measured to within perhaps 2 per cent. The reflecting power of snow for total solar radiation was found to be 70 per cent. In using the apparatus for the measurement of nocturnal radiation the glass hemisphere is removed. Upon the opening of the shutter the strip cools and thereby a deflection is produced in the attached galvanometer. This deflection, however, is brought to zero by introducing in the strip a heating current such that the temperature is restored to what it was before the shutter was removed. It is plain that the instrument may also be used for the measurement of the radiation of inclosures at fixed known temperatures which might be regarded as perfect radiators. We hope to make experiments of this kind in the effort to aid in the determination of the constant of Stefan's fourth power formula for the radiation of black bodies.

Invisible Companions of Binary Stars: G. C. COMSTOCK.

A large proportion of the visible stars are shown spectroscopically to be accompanied by companions not separately visible. In a very limited number of cases, such companions have been otherwise found. The presence of such invisible companions is possibly, or even probably, a normal stellar attribute. Aside from spectroscopic investigation, and in a field not accessible to it, the most promising method of search for such bodies is to be found in the disturbances produced by them in the motions of binary systems. This has been realized in a very few cases, *e. g.*, Zeta Cancri. The present paper suggests a simple method of testing suspected cases of this kind and shows by its application to Zeta Herculis that this star is probably a triple system in which the relative masses are of the order 100: 10: 1. The two smaller bodies are separated by only a twentieth of a second of arc.

Theory of Electric Conduction in Metals: EDWIN H. HALL.

In July, 1914, the author published[1] a paper in which he reached the conclusion that the so-called free electrons have little to do with electric conduction in metals but have an important function in thermo-electric action. In 1915 he made the suggestion[2] that the metal ions,—which are probably equal in numbers to the free electrons in a metal—may be of great effect in electric conduction. The idea is that during a collision between an atom and an ion an electron may be transferred from the atom to the ion by the action of a potential gradient due to an externally applied E.M.F., whereas in the collision of two atoms the electron would not pass. It can be shown that a comparatively small number of ions might serve to maintain a very powerful current. Some progress has been made in adapting this general theory to the requirements of Ohm's law and the known temperature relations of electric conduction in metals.

[1] *Proceedings of the American Academy of Arts and Sciences.*

[2] In *Il Nuovo Cimento,* the first number for 1915.

The Evolution of the Stars: F. R. MOULTON.

The Minor Planets discovered by James C. Watson: A. O. LEUSCHNER, Watson Medallist.

Afternoon Session

2:30–6:00 P.M.—Auditorium, National Museum.

Biography of Professor Theodore Nicholas Gill: WM. H. DALL. (By title.)

Biography of Professor Edward Singleton Holden: W. W. CAMPBELL. (By title.)

Biography of Professor Simon Newcomb: W. W. CAMPBELL. (By title.)

Report of the Work of the Committee upon the Panama Canal Slides: CHARLES R. VAN HISE, Chairman.

The Mechanics of the Panama Slides: H. FIELDING REID.

The Present State of Knowledge of the Extreme Ultra-Violet: THEODORE LYMAN, Director Jefferson Physical Laboratory, Harvard University. (By invitation of the Program Committee.)

The paper aims to present a résumé of the results which have been obtained in the region of very short wave-lengths since the researches of Schumann came to an end. The limit of the spectrum and the means which may be used to extend it, form the dominating feature of the article.

A Redetermination of e and N: ROBERT A. MILLIKAN.

In view of the far reaching significance of the electronic charge and the apparent adaptability of the "droplet method" to its very exact determination, an effort has been made during the past year to push this method to the limit of its possible precision. Droplets made from different substances and falling in different gases have been used. All the constant factors involved in the experiment have been redetermined. Details of the measurements will be published elsewhere. The final result is in exceedingly close agreement with the value obtained by the author and published in 1913, namely $e = 4.774 \times 10^{-10}$ electrostatic units.

The Relation of Investigational Work to the Enforcement of the Food and Drugs Act: CARL L. ALSBERG, Chief of the Bureau of Chemistry, United States Department of Agriculture. (By invitation of the Program Committee.)

Recent Exploration on the Mesa Verde National Park, Colorado: J. WALTER FEWKES.

Wherever we turn in certain sections of our southwest, we find mounds, ruins and evidences of prehistoric buildings. Their very multiplicity tends to confuse the mind, especially when it attempts to interpret their significance in culture history. The first step in anthropology, as in other natural sciences, is classificatory: Prehistoric culture is largely determined by architecture and ceramics. We need a reliable classification of these data. Manifestly linguistics or even physical anthropology are not adequate to give a satisfactory picture of the culture history of the people who inhabited a large part of our southwest. We must look to archeological data, especially architecture, for a knowledge of an unlettered prehistoric people. The object of the present communication is to record the progress of archeological work in the Mesa Verde National Park for the purpose of enlarging our knowledge of the prehistoric culture of southwestern Colorado. Incidentally it is an endeavor to show what the author regards as the scientific method of excavating southwestern ruins and of preparing and preserving them for future students. It has special reference to the field work in the summer of 1915 and is a continuation of work already accomplished in the years 1908, and 1909, when two large ruins—Spruce-tree House and Cliff Palace—were excavated and repaired to serve as type ruins of cliff dwellers. The plan of the field work in 1915 was the excavation of a mound on the point of the mesa opposite Cliff Palace. It was believed that a ruin belonging to a type unlike cliff dwellings was covered by this mound. The work was successful, and not only a new type of building was exposed, but the features brought to light indicate that it was constructed for rites connected with worship, in which the sun plays a prominent rôle. The method of excavation, repair and preservation of Sun Temple, as well as unique features developed, will be illustrated by lantern slides.

Further Evidence on the Nature of Crown Gall and Cancer and that Cancer in Plants Offers Strong Presumptive Evidence both of the Parasitic Origin and of the Essential Unity of the Various Forms of Cancer in Man and Animals: ERWIN F. SMITH.

WEDNESDAY, APRIL 19

1:00 P.M.—Auditorium, National Museum.

Second William Ellery Hale Lecture, by Henry Fairfield Osborn, President of the American Museum of Natural History. Subject "The Origin and Evolution of Life on the Earth." (Illustrated.)